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THE

GEOLOGICAL MAGAZINE

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No. I.—JANUARY, 1922.

EDITORIAL NOTES.

THE year that has just closed is in one respect a landmark in the history of the GEOLOGICAL MAGAZINE, in that we have to deplore the loss of the founder and Editor-in-chief. A treasured copy of the first number, dated July 1, 1864, now lying before us, bears the following inscription on its cover: "Edited by T. Rupert Jones, F.G.S., assisted by Henry Woodward, F.G.S., F.Z.S." Dr. Woodward very soon became principal editor, and performed the work up to June, 1919, and until within a very few weeks of his death he continued to take an interest in the editorship: thus his name appeared on the cover for a total period of over fifty-seven years. This surely must be a record for any periodical. It is perhaps of interest also to note that the *format* of the Magazine was in the first number to all intents and purposes identical with what it is now, and the classification of contents is very similar.

* * * * *

AT the beginning of this new volume we wish to inform our readers that although the Magazine is still far from being in a sound financial position, nevertheless, through the support of certain eminent geologists arrangements have been made which we hope and believe will secure continuance through the year. Once more at the risk of becoming tedious we would impress upon our readers the necessity for increasing the subscription list; a large circulation is the only sound basis for a periodical, scientific or otherwise. In the circumstances it will unfortunately be necessary to continue to ask contributors to pay the expenses entailed in illustrating their papers. This necessity is much regretted, as most geologists are not possessed of wealth, but it is unfortunately inevitable. While on this subject we should like to suggest to contributors one or two ways in which they can save expense. The first point is to send in all illustrations in a state allowing of direct reproduction, without any modification, or re-drawing. All line-drawings should be at least twice the size that they are intended to appear, and authors are particularly requested to bear in mind the subsequent reduction when adding letters and numbers to their drawings. In many cases when reproduced the lettering appears so small as to be illegible, or nearly so. It should also be borne in mind that shading cannot be reproduced in text figures, which must consist entirely of clear lines. The Editor is also strongly of opinion that for many classes of illustrations drawings are much more effective than photographs, and text-figures

cost less than plates. With regard to manuscripts, a good deal of editorial time is often wasted over such matters as inconsistencies in the use of capitals, italics, and hyphens, and by references not given in the standard form. It is perhaps hardly necessary to insist on the expense occasioned by extensive alterations in proofs. All this may seem somewhat ungracious, but our kind friends the authors of papers are asked to remember that the editorship is a purely honorary post, which has to be combined with the many other avocations of a somewhat busy life. This must be the excuse for this little lecture. After all, we are only asking contributors to edit their own papers.

* * * * *

Some time ago we ventured to comment in these columns on the attitude adopted by the Government towards the present deplorable position of the non-ferrous metalliferous mining industry of this country, a subject which must be of interest to all geologists. It was pointed out that the Secretary for Mines rather went out of his way to intimate that in no circumstances could any financial help be given. This contrasts strongly with the official attitude towards coal-mining. It is true that the country can continue to exist without metalliferous mines, while without coal any form of industry is impossible, nevertheless, the present state of affairs is no less than a disaster to the community. The chief factors in the situation are the low price of metals and the high price of coal, the result being that even with all possible economies working costs must exceed any possible value of the output. In justice to the miners in this industry it should be made clear that labour troubles have little to do with the matter; they are unemployed from no fault of their own, and would be only too glad to work for reduced wages, or almost any wages. But the general economic conditions are too strong for them. Furthermore, owing to the enormous price of coal it is found impossible in most cases to continue pumping the mines, which are now flooded, and many of them will probably never open again. Thus a valuable industry is being permanently lost to the country. So much for reconstruction after the war. We suggest that public money judiciously expended in subsidies towards keeping the mines in a condition to render resumption of work possible at some future date would be a wise investment and a true economy.

* * * * *

We have, however, an ulterior motive in raising this question here; namely, to call the attention of our readers to the terrible conditions of distress that prevail in the mining districts of Cornwall. We do not for a moment suggest that the miners and their families in other areas are less deserving, but we do not happen to be so well acquainted with the facts elsewhere. In the chief mining district of Western Cornwall, including the parishes of Camborne, Redruth,

Illogan, Gwennap, Stithian, St. Agnes, Chacewater, Baldhu, Wendron, Praze, Crowan, and Gwinear there are at present unemployed over 3,000 miners, representing some 16,000 dependents. All the mines are closed through no fault of the men, but purely on economic grounds, the price of tin now being considerably less than before the war. These men never had a high rate of wages, and received no inflated war bonus, and when the depression began many of them offered to return 20 per cent of their wages in the hope that thus it might be possible to keep the mines open. At present there is nothing for them except relief work on a very limited scale. We are glad to learn that there is a slight possibility of improved conditions owing to a projected large-scale amalgamation of mines, but it must be long before this can produce any appreciable effect. Meanwhile, but for the efforts of the local Mining Unemployment Relief Committee, great distress and actual destitution must prevail, and we desire most urgently to recommend this good cause to the generosity of our readers. Subscriptions or gifts in kind, especially clothing, boots, and shoes, may be sent to the Hon. Secretary of the Committee, the Rev. W. A. Bryant, Beacon Hill, Camborne, Cornwall.

* * * * *

The Syndics of the Cambridge University Press will shortly begin the publication of a new series, entitled *The Provinces of Ireland*. The volumes will be under the general editorship of Mr. George Fletcher, of the Department of Agriculture and Technical Instruction for Ireland; each will contain sections on ancient geography, topography, geology, botany, zoology, antiquities, architecture, administration, education, industries, and distinguished men; the contributors include Professor R. A. S. Macalister, Professor G. A. J. Cole, Professor Isaac Swain, Mr. R. Lloyd Praeger, Mr. E. C. R. Armstrong, Dr. R. I. Best, and Mr. George Fletcher. The volumes will be of convenient size (about 180 crown octavo pages each), and will be illustrated by maps, diagrams, and photographs. The volumes on Ulster and Munster will be ready immediately; these will be followed in the early spring by Leinster and Connaught, and the series will be completed by a somewhat larger volume dealing with Ireland as a whole. Finally, it may be added, that political controversy is rigidly excluded from all volumes of the series, and it is hoped that the plan of the books may be as acceptable in Belfast and Londonderry as in Dublin and Cork.

* * * * *

In November last Mr. James Mann Wordie, M.A., was admitted into a Fellowship at St. John's College, Cambridge. Mr. Wordie has paid special attention to glacial problems, and carried out explorations in circumpolar regions. He was on the Shackleton Antarctic Expedition of 1914–17, and has since visited Spitsbergen and Jan Mayen Island. On his return from the Antarctic Expedition he served in the war as a Lieutenant in the Royal Field Artillery.

Eminent Living Geologists:

Professor Sir T. W. Edgeworth David,

K.B.E., C.M.G., D.S.O., B.A., Hon. D.Sc. (Oxon.), F.R.S., F.G.S.,
Lieut.-Colonel Australian Imperial Forces.

(PLATE I.)

PROFESSOR SIR EDGEWORTH DAVID was born in 1858 at St. Fagan's Rectory, near Cardiff, and was educated at Magdalen College School, Oxford, becoming head of the school and captain of the football and boat clubs. In 1876 he was elected to the Senior Classical Scholarship at New College, Oxford, and graduated in 1880, having won further distinctions in classics and in athletics. He had included in his studies a course of geology under Professor Prestwich, and had commenced in South Wales his life-long research upon the problems of glaciation. His geological studies were continued in London under Professor Judd, at the Royal School of Mines, and in 1882 he was appointed to the Geological Survey of New South Wales, under the late Mr. C. S. Wilkinson. On his arrival in Sydney in November of that year he made an investigation of the very fossiliferous Silurian beds of Yass, and shortly afterwards commenced the study of the rich tin-bearing deep-leads and alluvium of New England, completing a large quarto memoir thereon in 1887. His duties led him to visit many parts of the State, but attention was now devoted chiefly to the Survey of the Hunter River Coalfield, which has occupied much of his time ever since; indeed, part only of his researches thereon has yet appeared. This investigation has been of immense value both economically and scientifically. The western portion, or Maitland coalfield, the extension of which was discovered during his survey, has proved the most important coalfield in Australasia. Here, too, were investigated the problems of the Permo-Carboniferous period, its glacial phenomena and peculiar flora and fauna. The distinguishing feature of all his work, the constant comparison of the area or problem immediately under investigation with kindred phenomena in other regions, has rendered this study of the Hunter River Coalfield of classic importance. During its progress he devoted also much attention to microscopical petrology, drawing up a classification of the rocks of the State and investigating, in particular, a series of those rare rocks, leucite-basalts. At the same time the broader problems of volcanic action attracted his interest. His official connexion with the Geological Survey ceased in 1891 on his appointment to the Chair of Geology in the University of Sydney.

In 1891 the Geological School of that University was quite a small department, but under the enthusiastic teaching of its new head, and with the stimulus of the rapidly increasing importance of the mining industries, its influence spread widely throughout Australia,

PROFESSOR SIR T. W. EDGEWORTH DAVID.

[*To face p.* 1

and it has become a large institution through which more than two hundred students pass each year. Professor David was soon recognized as a leading scientist in Australia. He was President of the Geological Section of the Australasian Association for the Advancement of Science in Hobart in 1892 and at Brisbane in 1895, of the Linnean Society of New South Wales in 1894–5, and of the Royal Society of New South Wales in 1896. In his addresses to these bodies he gave valuable summaries of the knowledge of volcanic action, the structural features, and evidence for glaciation throughout Australia, and the Mesozoic history of Eastern Australia and New Zealand. In 1897 he was appointed to the Committee of the Royal Society of England for investigating the structure of coral reefs, and was entrusted with the leadership of the second coral-boring expedition to Funafuti, where, after overcoming many difficulties, he succeeded in obtaining a complete core, from a bore sunk to the depth of 1,118 feet. He also carried out a survey of the atoll and investigations on the growth of corals.[1] The examination of the material thus obtained yielded most important information. Quickly following upon this work was the conclusion of his studies of the immense development of Devonian radiolarian rocks in New South Wales, in which the evidence is clear that these were formed in comparatively shallow water, and not in abyssal depths, such as many authorities believed to be essential to the deposition of radiolarian sediment. The value of these researches was recognized in the award to him of the Bigsby Medal of the Geological Society of London (1899) and his election as a Fellow of the Royal Society (1900).

In 1904 Professor David presided over the Australasian Association for the Advancement of Science, which met at Dunedin, New Zealand, and gave an inspiring address upon the aims and ideals of Australasian Science. He continued to devote special attention to the Australian evidence of past glaciation, Pleistocene, Permo-Carboniferous and Cambrian (?), and in 1906 visited the glaciated districts of Southern India on his way to the meeting of the International Geological Congress in Mexico, before which he presented a discussion of the evidence and explanatory hypotheses for such climatic fluctuations. At this time also appeared the first instalment of his researches on the Hunter River Coalfield, a large quarto memoir with many maps and sections, devoted especially to matters of economic importance.

His interest in the problem of glaciation led him to accept Lieut. Shackleton's invitation to him to join the British Antarctic Expedition of 1907–09, and while in the Far South he investigated the meteorological features, general geology, and the former greater extent of ice in Antarctica, made the first ascent of Mount Erebus, and, in company with his former student, now Sir Douglas Mawson,

[1] The adventures of this Expedition are delightfully told in Mrs. David's book, *Funafuti, an Unscientific Account of a Scientific Expedition.*

made the first journey to the South Magnetic Polar area, a journey involving great physical suffering and hairbreadth escapes from death. Indeed, the rescue of the small party seemed to be almost a matter of chance. During his absence from Australia the Australasian Association for the Advancement of Science awarded to him their highest distinction, the Mueller Memorial Medal.

With the return of the Expedition to Australia there was aroused great public interest in Antarctic exploration, due in no small measure to the personality of Professor David himself, whose name had literally become a household word. The urgent demand of the public to see and hear him, together with the need for securing funds for the publication of the Scientific Memoirs of the Expedition, caused him to travel on a lecturing tour throughout the Commonwealth. Meantime, the need arose for organizing and obtaining support for the Australasian Antarctic Expedition under Dr. Mawson, making arrangements also in connexion with Captain Scott's last Expedition, and later securing support for Shackleton's second Expedition. He also arranged for the detailed study of the extensive geological collections from the Antarctic by a group of workers, mostly his former students, and distributed other material amongst Australian scientists for investigation. He was also for a second time President of the Royal Society of New South Wales, and prepared as his address an illuminating summary of the tectonics of Australia. During this strenuous period his magnificent volume on Antarctic geology was written in co-operation with Mr. R. E. Priestley and published in 1914. He received the honour of C.M.G. in 1910.

His position as the doyen of Australasian science was acknowledged in his re-election to the Presidency of the Australasian Association in 1913, an especially important position in view of the approaching visit of the parent British Association in the following year. His presidential address dealt with Antarctic meteorology and its influence on that of Australasia. Arrangements for the visit of the British Association involved much organization, together with the preparation of a valuable series of articles on the geology of Australia and New Guinea, for the Federal and State Handbooks to be issued in connexion therewith. At the Sydney meeting of this Association Professor J. T. Wilson and he first exhibited the Talgai skull, an anthropological discovery of the highest importance. Shortly after this he was awarded the Count Malle Brun Medal of the Geographical Society of France and the Wollaston Medal of the Geological Society of London.

On the outbreak of the Great War he assisted the Government in many capacities, suggested and took great part in the organization of a battalion of miners, staffed largely by his own former students. This he himself joined as Major, and arrived in France in May, 1916, and became geological adviser to the Controller of Mining in the First, Second, and Third Armies. After a narrow escape from death at Vimy Ridge in September, 1916, he was appointed to General

Headquarters as Geological Adviser to the Inspector of Mines of the British Expeditionary Forces, and with Captain W. B. R. King was responsible for all the geological work in the British Armies in France. This was especially important in guiding tunnelling operations among very porous strata below ground-water level. "If it had not been for this work of Colonel David, portions of our mining system would have been completely flooded out and lost."[1] He was promoted to the rank of Lieut.-Colonel, received the D.S.O., and was knighted during the past year. The Council of the Royal Society of New South Wales took advantage of his absence to award him the Clarke Memorial Medal.

Back once more in Sydney, Professor David returned with much energy to his old researches, especially the evidence of glaciation from Middle to Upper Carboniferous times, first discovered by him during the visit of the British Association in 1914. This had been further investigated in his absence by his former student, Mr. C. A. Süssmilch, with whom he now completed an account of the phenomena, including a wonderful series of seasonally-banded rocks comparable with the "varve" rocks of De Geer, and also added a general discussion of the relationship of Carboniferous and Permian rocks in various parts of the world. He has arranged during the present year to visit many of the critical areas throughout Australia in preparation for his long-awaited book on the geology of the continent.

Besides carrying out this great amount of research work, Professor David has always taken an active part in University organization as Dean of the Faculty of Science, Chairman of the Professorial Board, and member of the University Senate, and is also a trustee of the Australian Museum. His advice is constantly sought by his fellow-geologists, official and academic, throughout the Commonwealth, in which he has travelled widely. So, also, his services are in frequent demand and always given freely to the Government in all matters of scientific organization, and he has been a member of several Royal Commissions dealing with coal and artesian water supply. As a public speaker he is most successful, attracting attention always by his vivid presentation of his subject, enthusiasm, and keen sense of humour. No sketch of his career could, however, omit to mention the secret of his great influence, a winning personality which combines with high scientific attainment a noble ideal of duty, extraordinary generosity of thought and deed, and a courtly charm of manner that has endeared him to all who have had the privilege of meeting him. These would echo heartily the words of General Liddel (Chief of Staff, Royal Engineers): "In regard to Colonel David I may say on behalf of R.E. officers that we regarded him always with the most affectionate admiration; he was one of the finest characters we have ever met."

[1] For an account of this work see W. B. R. King, "Geological Work on the Western Front," *Geographical Journal*, October, 1919, pp. 201–21.

Professor David was married in 1885 to Miss C. M. Mallet, and has two daughters and a son, Captain W. E. David, R.A.M.C., who won the Military Cross for bravery and devotion to duty at Loos and Ypres.

BIBLIOGRAPHY.

1881. Evidences of Glacial Action in the neighbourhood of Cardiff: Trans. Cardiff Naturalists Society, pp. 1–19.

1883. Evidences of Glacial Action in South Brecknockshire and East Glamorganshire: Quart. Journ. Geol. Soc., xxxix, pp. 39–54.

Report on the Fossiliferous Beds at Yass: Annual Report Dept. Mines New South Wales for 1882, p. 148, with map.

1884. Progress Reports for 1883: ibid. (1883), pp. 155–157, with map.

1885. Progress Reports for 1884: ibid (1884), pp. 153–155.

1886. Progress Reports for 1885: ibid. (1885), pp. 136–140.

Notes on some Points of Basalt Eruption in New South Wales: Transactions of the Geological Society of Australia, vol. i, pt. 1, pp. 24–30.

1887. Progress Reports for 1886: Ann. Rept. Dept. Mines N.S.W., 1886, pp. 144–166, with maps, etc.

Geology of the Vegetable Creek Tin-mining Field, New England District: Memoir No. 1, Geological Survey of New South Wales, pp. 169 (4vo), map and 9 sections.

On the Evidence of Glacial Action in the Carboniferous and Hawkesbury Series, New South Wales: Quart. Journ. Geol. Soc., xliii, pp. 190–196.

1888. Progress Reports for 1887: Ann Rept. Dept. Mines N.S.W., pp. 145–154.

Notes on remarkable variety of intrusive Basalt from Bulli Mountains near Bulli, and a rock belonging to the Gabbro group: Proc Linn. Soc. N.S.W., pp. 423–424.

Notes on (*a*) The Occurrence of Basalt-glass (Tachylite) in the Vegetable Creek District, New England;
(*b*) The Occurrence of Dacite at Monvale;
(*c*) A Pitchstone from Port Stephens;
(*d*) Chiastolite in a Stone-hatchet found at Strathbogis near Vegetable Creek, ibid., pp. 1078–1085.

1889. Progress Reports for 1888: Ann. Rept. Dept. Mines, 1888, pp. 164–176.

Origin of Laterite in the New England District of New South Wales: Trans. Aust. Assoc. Advancement of Science, i, pp. 233–241

Cupriferous Tuffs of the Passage beds between the Triassic Hawkesbury Series and the Permo-Carboniferous Coal Measures of New South Wales: ibid., pp. 275–290.

Micropetrographical Notes on some of the Hydro-thermal Rocks of New South Wales: ibid., pp. 290–291.

Report on the Discovery of Human Remains in the Sand and Pumice Beds at Long Bay: Rec. Geol. Sur. N.S.W., vol. i, pp. 9–15. With R. Etheridge, jun.

On the Physical Characters of Telluric-Bismuth Ores from Norongo, near Captain's Flat: ibid., pp. 29–30.

On the Examination of an Aboriginal Rock Shelter and Kitchen Midden at North Harbour, Port Jackson: ibid., pp. 140–145. With R. Etheridge, jun.

The Leucite-basalts of New South Wales: ibid, pp. 153–172. With W. Anderson.

Notes on a Collection of Igneous Rocks from Lord Howe Island: Memoirs Australian Museum, No. 2, pp. 3–6.

Note on the Origin of Kerosene Shale: Proc. Linn. Soc. N.S.W., pp. 483–500.

1890. Progress Reports for 1889: Ann. Rept. Dept. Mines (1889), pp. 209–233.

Proposed Petrographical Classification of the Rocks of New South Wales: Rec. Geol. Surv. N.S.W., ii, pp. 1–15.

The Raised Beaches of the Hunter River Delta : ibid., pp. 37–52. With R. Etheridge, jun.

A Correlation of the Coalfields of New South Wales : Trans. Aust. Assoc. Advance. Sci., ii, pp. 459–466.

The Coal Measures of New South Wales and their Associated Eruptive Rocks : Journ. and Proc. Roy. Soc. N.S.W., pp. 257–270.

Geological Notes—

(*a*) On the Laccolites of the Junction Mine near Mandurama ;

(*b*) On the Occurrences of *Glossopteris* in a remarkable state of preservation in the Greta Coal Measures at Richmond Vale, near Maitland ;

(*c*) On the Occurrence of Andesitic lava at the Canoblas, near Orange : Proc. Linn. Soc. N.S.W., pp. 421–428.

1891. Progress Reports for 1890 : Ann. Rept. Dept. Mines, 1896, pp. 219–260.

Notes on a Collection of Rocks and Minerals from Mount Morgan near Rockhampton, Queensland : Rec. Geol. Surv. N.S.W., ii, pp. 85–93.

The Associated Mines and Volatility of Gold : ibid., pp. 100–108.

Notes on Mr. J. C. H. Mingaye's Analyses of New South Wales Coals and Cokes : ibid., pp. 117–118

Artesian Water in New South Wales, Preliminary Note : Journ. Proc. Roy. Soc. N.S.W., pp. 286–296.

1892. Progress Reports for 1891 : Ann. Rept. Dept. Mines N.S.W., pp. 217–248.

Geology and Mineralogy Course, Australasian Home Reader I, No. 2 (June), pp. 36-41 ; No. 4 (August), 106–109 ; No. 5 (September), 141–145 ; No. 6 (October), 166–171 ; No. 8 (December), 228–234.

1893. Report on Kerosene Shale Deposits, Doughboy Hollow, near Murrurundi : Ann. Rept. Dept. Mines N.S.W., 1892, pp. 159–163.

On the Occurrence of *Lepidodendron Australe* in the Devonian Rocks of New South Wales : Rec. Geol. Surv. N.S.W., iii, pp. 194–201. With E. F. Pittmann.

Presidential Address : Volcanic Action in Eastern Australia and Tasmania : Rept. Aus. Assoc. Adv. Sci., Hobart, 1892, iv, Sec. C., pp. 1–18.

Note on the Occurrence of the Mineral Sphene in Granite from Bathurst, New South Wales : Proc. Linn. Soc., N.S.W., Ser. 2, viii, pt. 1, pp. 44–45.

Note on the Occurrence of *Lepidodendron* in Upper Devonian rocks at Mount Lambie, near Rydal, N.S.W. : Proc. Linn. Soc. N.S.W., 1893, ser. II, viii, pt. 1, pp. 121–125.

1894. Contribution to the study of Volcanic Action in Eastern Australia : Rept. Aus. Assoc. Adv. Sci., Adelaide, 1893-1894, v, pp. 1–7.

Report of Research Committee to collect evidence as to Glacial Action in Australia in Tertiary or Post-Tertiary Times : Trans. Aust. Assoc. Adv. Sci., v, pp. 229–132.

Preliminary Note on the Occurrence of a Chromite-bearing Rock in Basalt at the Pennant Hills Quarry, near Parramatta : Journ. Proc. Roy. Soc. N.S.W., 1893, 1894, xvii, pp. 401–406 With W. F. Smeeth and J. A. Watt.

Note on the Occurrence of a calcareous Sandstone, allied to Fontainebleau Sandstone, at Rock Lily, near Narrabeen : Journ. Proc. Roy. Soc. N.S.W., 1893, 1894, xxvii, pp. 406–407.

Note on the Occurrence of Barytes at Five Dock and also at the Pennant Hills Quarry, near Parramatta, with a suggestion as to the possible Origin of Barytes in the Hawkesbury Sandstone : Journ. Proc. Roy. Soc. N.S.W., 1893, 1894, xxvii, 407–408.

Notes on Artesian Water in New South Wales and Queensland, Part II : Journ. Proc. Roy. Soc. N.S.W., 1893, 1894, xxvii, pp. 408–443.

Notes on the Cremorne Bore : Journ. Proc. Roy. Soc. N.S.W., 1893, 1894, xxvii, pp. 443–465. With E. F. Pittman.

A Sketch of our present knowledge of the Geological History of Australia, Tasmania, and New Zealand from Cretaceous time down to the Permo-Carboniferous Period: Proc. Linn. Soc. N.S.W., 1894, 2 ser. viii, pp. 540–607, plates xxvii–xxviii.

Note on Stratigraphical distribution of *Glossopteris* in Australia: Proc. Linn. Soc. N.S.W., 1894, 2 ser. ix, pt. 2, pp. 249–257. Forming part of a paper on *Glossopteris* by R. Etheridge, jun.

1895. Presidential Address: Proc. Linn. Soc. N.S.W., 1895, 2 ser. x, pt. 1, pp. 134–161.

Hunting an Ice Age: The Australian Home Reader IV (July, pp. 65–68.

1896. Evidences of Glacial Action in Australia and Tasmania. Presidential Address to Section C: Rept. Aus. Assoc. Adv. Sci., Brisbane, 1895, 1896, vi, pp. 58–98.

Evidence of Glaciation at Hallett's Cove: Rept. Aus. Assoc. Adv. Sci., Brisbane, 1895, 1896, vi, pp. 315–330, plates xlix-l. With R. Tate and W. Howchin.

Notes on Antarctic Rocks collected by Mr. C. R. Borchgrevinck: Journ. Proc. Roy. Soc. N.S.W., 1895, 1896, xxix, pp. 461–492, plates xiii–xv. With W. F. Smeeth and J. A. Schofield.

Evidences of Glacial Action in Australia in Permo-Carboniferous time: Quart. Journ. Geol. Soc., 1896, lii, pp. 289–301.

1897. On the Occurrence of a Submerged Forest, with remains of the Dugong, at Shea's Creek, near Sydney: Journ. Proc. Roy. Soc. N.S.W., 1896, 1897, xxx, pp. 158–185. With R. Etheridge, jun., and J .W. Grimshaw.

Note on the Occurrence of Diatomaceous Earth at the Warumbingle Mountains, New South Wales: Proc. Linn. Soc. N.S.W., 1896, 2 ser. xi, pt. 2, pp. 261–268.

Anniversary Address. Summary of the present state of our knowledge as to the structure and origin of the Blue Mountains of N.S.W.: Journ. Proc. Roy. Soc. N.S.W., 1896, 1897, xxx, pp. 1–69.

Sill Structure and Fossils in Eruptive Rocks in New South Wales: Journ. Roy. Soc. N.S.W., 1896, 1897, xxx, pp. 285–290.

The Occurrence of Radiolaria in Palæozoic Rocks in New South Wales: Proc. Linn. Soc. N.S.W., 1897, 2 ser. xi, pt. 4, pp. 553–570.

Note on the Occurrence of Casts of Radiolaria in pre-Cambrian (?) Rocks, South Australia: Proc. Linn. Soc. N.S.W., 1897, 2 ser., xi, pt. 4, pp. 571–583. With W. Howchin.

Notes on the Glacial Features of the Inman Valley Yankaelila and Cape Jervis District: Trans. Roy. Soc. South Aust., pp. 61–67. With W. Howchin.

1898. Further evidence as to glacial action in the Bacchus Marsh District, Victoria: Rept. Aus. Assoc. Adv. Sci., Sydney, 1898, pp. 361–365, plates xvii–xviii. With C. C. Brittlebank and C. Sweet.

Report on the Occurrence of Glacial Boulders at Yellow Cliff, Crown Point Station, Finke Valley, Central Australia: ibid., pp. 109–113; also Evidence of Glacial Action in the Port Victor and Inman Valley Districts: ibid., pp. 114–127. With other Members of Glacial Research Committee.

Descriptions of the Palæozoic Fossils of New South Wales: Translation from the French of L. G. de Koninck, Pal. Memoir No. 6, Geol. Surv., N.S.W. With Mrs. David and W. S. Dun.

Stratigraphical Note in the above Memoir, pp. 290–293.

1899. Records of Rock Temperatures at Sydney Harbour Colliery, Birthday Shaft, Balmain, Sydney: Journ. Proc. Roy. Soc. N.S.W., 1899, 1900, xxxiii, pp. 207–224. With J. L. C. Rae and E. F. Pittman.

Discovery of Glaciated Boulders at base of Permo-Carboniferous system, Lochinvar, N.S.W.: Journ. Proc. Roy. Soc. N.S.W., 1899, 1900, xxxiii, pp. 154–159.

On the Palæozoic Radiolarian Rocks of New South Wales: Quart. Journ. Geol. Soc., 1899, lv, pp. 16–37. With E. F. Pittman.

1900. Note on the Edible Earth from Fiji: Journ. Proc. Roy. Soc. N.S.W., 1899, 1900, xxxiii, pp. 224–227. With B. G. Corney and F. B. Guthrie.

Notes on the Limestones and general Geology of the Fiji Islands, with special reference to the Lau group; based upon surveys made by Alexander Agassiz, with a preface by Professor David: Bull. Mus. Comp. Zool. Harvard Coll., Geol. Series, 1900, xxxviii. With E. C. Andrews.

1901. Geological notes on Kosciusko, with special reference to Evidences of Glacial Action: Proc. Linn. Soc. N.S.W., 1901, 2 ser. xxvi, pt. i (No. 101), pp. 26–74. With R. Helms and E. F. Pittman.

Note on the Occurrence of Diatoms, Radiolaria and Infusoria in the Rolling Downs Formation, Lower Cretaceous, Queensland: Proc. Linn. Soc. N.S.W., 1901, 2 ser. xvi, pt. ii (No. 102), pp. 299–309. With W. S. Dun and W. H. Rands.

1902. On the Occurrence of a Variety of Tinguaite at Kosciusko, N.S.W.: Journ. Proc. Roy. Soc. N.S.W., 1902, 1901, xxxv, pp. 347–382. With F. B. Guthrie and W. G. Woolnough.

The Science Departments (in the University of Sydney): Hermes. Jubilee number, 1902, pp. 101–104.

Occurrence of Gadolinite in West Australia: Journ. Proc. Roy. Soc. N.S.W. 1902, 1903, xxxvi, pp. 286–289. With B. F. Davis and W. G. Woolnough.

1903. An important Geological Fault at Kurrajong Heights, New South Wales: Journ. Proc. Roy. Soc. N.S.W., 1902, 1903, xxxvi, 359–370.

Report of the Glacial Committee: Rept. Aus. Assoc. Adv. Sci., Hobart, 1902, 1903, ix, sec. C, pp. 190–204.

University Science Teaching: Record of the Jubilee Celebrations of the University of Sydney: Sydney, 1903, 8vo, pp. 93–121.

1904. Irrigation Geologically considered, with special reference to the Artesian area of New South Wales: Journ. Proc. Roy. Soc. N.S.W., 1903, 1904, xxxvii, Engineering Section, pp. ciii–cliii. With E. F. Pittman.

Narrative of the Second and Third Expedition, Funafuti: The Atoll of Funafuti: Rept. of the Coral Reef Committee of the Royal Society, London, 1904, sec. 4, pp. 40–60.

The Geology of Funafuti: The Atoll of Funafuti: Report of the Coral Reef Committee of the Royal Society, London, 1904, sec. 5, pp. 61–124, pl. i–xix. With G. Sweet.

Report on Dredging at Funafuti: The Atoll of Funafuti: Rept. of the Coral Reef Committee of the Royal Society, London, 1904, sec. 7, pp. 151–159. With G. H. Halligar and A. E. Finckh.

1905. The Flood Silt of the Hunter and Hawkesbury rivers, New South Wales: Journ. Proc. Roy. Soc. N.S.W., 1904, 1905, xxxviii, pp. 191–202. With F. B. Guthrie.

Occurrence of the Pseudomorph Glendonite in New South Wales, Part I. Records Geol. Surv. N.S.W., December, 1905, viii, pt. ii, p. 161. With T. G. Taylor.

Inaugural Address; The Aims and Ideals of Australasian Science: Rept. Aus. Assoc. Adv. Sci., Dunedin, 1904, 1905, x, pp. 1–43.

1906. Glaciation in Lower Cambrian, possibly in Pre-Cambrian time: Congres Geologique International, Mexico, 1906, pt. i, pp. 271–274.

Les Conditions du Climat aux Epoques Géologiques: Congres Geologique International, Mexico, 1906, pt. i, pp. 275–898.

Conditions of Climate at different Geological epochs, with special reference to Glacial epochs: Congrès Géologique International, Mexico, 1906, pt. i, pp. 437–482.

Occurrence of Diamonds in Matrix at Pike and O'Donnell's claim, Oakey Creek, near Inverell: Congrès Géologique International, Mexico, 1906, pt. ii, pp. 1201–1210.

1907. The Occurrence of Diamonds in the Matrix at Oakey Creek, near Inverell, New South Wales: Rept. Brit. Assoc. Adv. Sci., York, 1906, 1907, pp. 562–563.

Notes on the Permo-Carboniferous Coalfields of Australasia: Rept. Brit. Assoc. Adv. Sci. York, 1906, 1907, p. 576.

Further Note on the Occurrence of Diamonds in the Matrix in New South Wales: Rept. Brit. Assoc. Adv. Sci., York, 1906, 1907, p. 562. Abstract.

The Geology of the Hunter River Coal Measures, New South Wales; General Geology and the Development of the Greta Coal Measure: Mem. Geol. Surv. N.S.W., 4, 1907, pt. i, pp. 1–372.

1908. Introductory Note on the Report of the Glacial Committee: Rept. Aus. Assoc. Adv. Sci. Adelaide, 1907, 1908, xi, pp. 263–264.

Permo-Carboniferous beds at Wynyard, near Table Cape, Tasmania: Rept. Aus. Assoc. Adv. Sci. Adelaide, 1907, 1908, xi, pp. 274–279

Some problems of Australian Glaciation: Rept Aus. Assoc. Adv. Sci., Adelaide, 1907, 1908, xi, pp. 457–465.

Geological Notes on Kosciusko, with special evidences of Glacial Action: Proc. Linn. Soc. N.S.W., 1908, 2 ser., xxxiii, pt. iii, pp. 657–668, pl. xxiii.

Revision of Chapter IV, Volume III: Sollas' translation of the Face of the Earth.

1909. Evidence of recent submergence of coast at Marrabeen: Journ. Proc. Roy. Soc. N.S.W., 1908, 1909, xlii, pp. 229–237. With G. H. Halligan.

Professor David's narrative of a journey to the South Magnetic Pole: The Heart of the Antarctic, by E. H. Shackleton, Lond., 1909, vol. ii, pp. 73–222.

Geological Observations in Antarctica by the British Antarctic Expedition, 1907–1909: The Heart of the Antarctic, 1909, ii, pp. 268–310. With R. E. Priestley.

Meteorology; A Summary of Results: The Heart of the Antarctic, 1909, ii, pp 376–383. With Lieut. Adams.

1911. Presidential Address delivered to the Royal Society of New South Wales, 3rd May, 1911: Journ. Proc. Roy. Soc. N.S.W. for 1911, xlv, pt. i, pp. 1–60.

1912. New South Wales, Historical, Physiographical, and Economic: By A. W. Jose, T. Griffith Taylor, W. G. Woolnough; edited by T. W. Edgeworth David. Melbourne: Whitcombe & Tombs, Ltd. (1912), pp. 12 (inc. 4 blank), 372.

Geological notes of the British Antarctic Expedition, 1907–09: Extrait de Compte Rendu du XIe Congrès Géologique International, 1912, pp. 767–811. With R. E. Priestley.

1913. Discovery by the Australasian Antarctic Expedition of important Submarine Banks: Geog. Journ., May, 1913, xli, No. 5, pp. 461–463, 2 fig.

Mawson's Australasian Antarctic Expedition: Nature, 21st August, 1913, xci, p. 65.

Antarctic Problems. Paper read before the Royal Geographical Society, Nature, 19th February, 1914, xcii, pp. 700–702.

Note on an Expedition to Dutch New Guinea: Paper delivered by A. F. R. Wollaston before the Roy. Geog. Soc., London, Geog. Journ. March, 1914, xliii, No. 3, pp. 272–273.

Antarctica and some of its Problems: Geog. Journ., 1914, xliii, No. 6, pp. 605–630, 8 figs.

Remarks on Physiography and Glacial Geology of East Antarctica: Paper read before the Roy. Geog. Soc., London; Geog. Journ., December, 1914, xliv, No. 6, pp. 566–568.

Presidential Address to Australasian Association for the Advancement of Science: Reprinted from Rept. Aust. Assoc. Adv. Sci., Melbourne, 1913, xiv, pp. xliii-xcii. Issued December, 1913.

1914. British Antarctic Expedition, 1907–09, under the command of Sir E. H. Shackleton, C.V.O.: Reports on the Scientific Investigations, Geology, vol. i, pp. xxiv, 319, 96 plates, 67 text-figures. With R. E. Priestley.

The Tectonic Geology of New South Wales: B.A.A.S. Handbook for New South Wales, pp. 567–577.

Permo-Carboniferous System: B.A.A.S. Handbook for New South Wales, pp. 590–600.

Tertiary Stratigraphy for New South Wales: B.A.A.S. Handbook for New South Wales, pp. 608*a*–608.

The Geology of the Commonwealth. The Commonwealth of Australia Federal Handbook prepared in connexion with the eighty-fourth meeting of the Brit. Assoc. Adv. Sci. Melbourne, pp. 241–290, plates i–viii, 6 text-figures.

Igneous Rocks: The Commonwealth of Australia Federal Handbook, pp. 302–314. With E. W. Skeats.

Metamorphic Rocks: The Commonwealth of Australia Federal Handbook, pp. 314–316. With E. W. Skeats.

Papua: The Commonwealth of Australia Federal Handbook, pp. 316–325, plates vii–xi.

The Talgai Skull: Scientific Australia, September, 1914, xx, No. 1, pp. 4–5. With J. T. Wilson.

Sir Norman Maclaurin — An Appreciation: The Review, 30th September, 1914, xv, No. 9, p. 440.

A Preliminary Communication on an Australian Cranium of probable Pleistocene Age: Med. Journ. of Aust., 26th September, i, No. 13, p. 308. With J. T. Wilson.

1915. On the term Permo-Carboniferous and on the Correlation of that System: Rept. Brit. Assoc. Adv. Sci. Aust., 1914, pp. 379–380. With W. S. Dun.

Preliminary Communication on an Australian Cranium of a probable Pleistocene Age: Rept. Brit. Assoc. Adv. Sci. Aust., 1914, pp. 531. With J. T. Wilson.

1916. Sections of Australian Fossil Plants: Reports of the Committee appointed to cut sections of Australian Fossil Plants: Rept. Brit Assoc. Adv. Sci., Manchester, 1915, p. 231. With others.

Nomenclature of the Carboniferous, Permo-Carboniferous and Permian Rocks of the Southern Hemisphere; Report of the Australian Members of the Committee: Rept. Brit. Assoc. Adv. Sci., Manchester, 1915, p. 263–266. With others.

Discussion of the above Notes and Table: Rept. Brit. Assoc. Adv. Sci., Manchester, 1915, pp. 266–274.

Preface, British Antarctic Expedition 1907–09: Rept. of Scientific Investigations Geology ii, pp. v, vi. With R. E. Priestley.

1919. Reports cited by Captain W. B. R. King; Geological work on the Western Front: Geog. Journ., October, 1919, pp. 201–221, especially pp. 206–208–9.

1920. Sequence, Glaciation, and Correlation of the Carboniferous Rocks of the Hunter River District, New South Wales: Journ. Proc. Roy. Soc. N.S.W., liii, pp. 246–338. With C. A. Süssmilch, W. R. Browne, and A. B. Walkom.

ORIGINAL ARTICLES.

Note on Traces of Recent Ice-action in N. China.

By J. S. Lee, M.Sc., National University, Peking.

(PLATE II.)

THE question whether N. China was under the grip of Polar severity towards the close of the Tertiary or the beginning of the Pleistocene time, and whether there was sufficient precipitation to allow the existence of large glaciers even if the temperature had become for a time arctic, has, on account of its important bearing on the problem of the cause of glaciation, aroused from time to time forcible but conflicting arguments. As cumulative evidence tends to show the wide prevalence of desert conditions all over N. China throughout recent geological times, geologists seem to have generally agreed, and naturally so, to provide a negative answer to the second part of the question. But as to the first part, it remains so far completely shrouded in doubt. In matter of this kind nobody would expect to wrest out truth by mere theoretical contention. Any relevant fact, therefore, deserves to be placed on record.

Two cases are now available that seem to afford a strong ground to prevent us from admitting the hitherto accepted view.

(1) In journeying across the coal-basin of Sha-ho-hsien, southern Chi-li, I sighted from a distance a singular hill-range of moderate height, called the Sha-yuan-ling. The range possesses a round contour, and trends E.S.E.–W.N.W. The E.S.E. end of the range is separated by a deep valley from another hill-range running N.N.E.; and the W.N.W. part of the Sha-yuan-ling gradually flattens out towards the loess plain so that the whole hill constitutes a topographical unit.

As I approached the Sha-yuan-ling from the south-west strange boulders began to appear. Being pre-occupied by the idea that desert conditions prevailed throughout recent geological times in N. China, I sought all conceivable ways other than glaciation to account for the presence of these erratics, but in vain, for the topographical features of this isolated hill do not admit the assumption that they have rolled down from the hills to the south-east; still less likely were they brought down by a pre-existing stream. Before, however, I reached the northern foot of the Sha-yuan-ling a cliff on the hillside suddenly came in sight (Fig. 1). Large and small blocks or boulders are seen in this natural profile. They are scattered at random in a clayey or sandy material, and are generally polished on one or two, but rarely more than two, surfaces. The edges of the blocks are in the majority of cases fairly sharp except those between the polished surfaces, which are as a rule rounded. Although the finer material that forms a part of the deposit bears here and there suggestions of

stratification, they disappear in a very short distance. The rock is as a whole unstratified and unconsolidated. Were it found in N.W. Europe or N. America, I doubt if any one would hesitate for a moment to call it Drift or Till. It was this general appearance of the rock that inspired the conviction that if a patient search be continued striated pebbles or blocks could no doubt be found among the fragments.

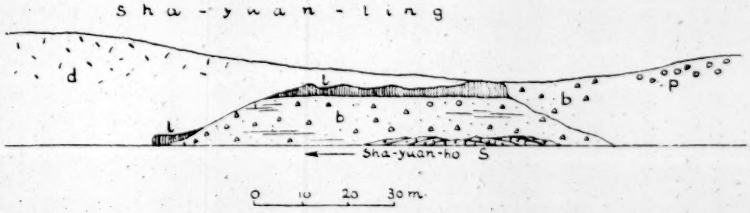

FIG. 1.—The Sha-yuan-ling from the S.W.—l, loess; p, pebble-bed; b, boulder-bed; s, sandstone; d, dolerite.

A systematic search was at once started. Keeping always a particular object in view, I could perceive now and then suggestions of obliterated striation on the polished surfaces. After toiling for more than two hours, a large slab half-buried (Fig. 2) was

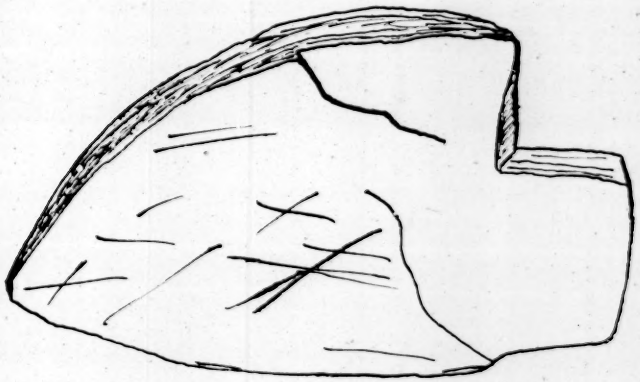

FIG. 2.—A striated slab found in the Sha-ho-hsien Coalfield, Chi-li, N. China. Max. length and width, 125 × 70 cm.

found; on its flat surface at least three sets of striæ could be clearly observed. Following this find two more striated fragments of similar character fell under my notice (Pl. II, Fig. 1). Judging from the extraordinarily regular parallel grooves and ridges on their flat surfaces, the suspicion is not absent that they might be merely slickensides. The origin of these fragments, however, does not seem to affect in a serious way the evidential value of the first slab; for evidence is brought forward by Coaz, Heim,

Pasquier, and others that an avalanche sometimes slides down hill-slopes like a landslip, and heaps up masses of fragmentary rock or boulders in the valley.[1] Moreover, it is well within all possibilities that some of the fragmentary rocks had already undergone a process of rubbing before they were transported by the ice.

The boulders largely consist of sandstones of many kinds. Some of them are members of the coal-bearing series, others are foreign and unknown in origin. A green tuff-like sandstone and a hard quartz-sandstone frequently occur in huge blocks with one side well polished. The former is entirely unknown in the surrounding country; the latter caps the hills to the south-east of the Sha-yuan-ling, and extends discontinuously for more than 60 miles southward. Cherts and wind-faceted pebbles are now and then found among the more comminuted material. Well-rounded quartzitic pebbles of the size of Easter eggs rarely occur, and appear to be limited to the upper part of the deposit. The Sinian Limestone which forms the high range of the Tai-hang to the west is singularly absent; while the presence of the hard quartz-sandstone, dolerite, etc., indicates that a part of the boulders are of local origin or arrived from the south.

The deposit rests upon a denuded anticline, pitching slightly towards the north-east. The exposed part of the anticline consists of a buff sandstone which lies well above the zone of *Pterophyllum carbonarium* Schenk.[2] Above the deposit there is a mantle of loess. As far as can be judged from the suggestions of stratification, both the loess and the rock immediately underlying it are slightly arched in a conformable manner. No signs of erosion were detected in the contact plane of the two, though sharply defined. Thus it appears that there has never been any violent tectonic disturbance, but possibly a pre-loess landslip or avalanche that might have given rise to the striation on some of the boulders. But landslip alone cannot explain all the observed facts.

A hummocky hill forms the eastern portion of the Sha-yuan-ling. The upper part of it is composed of dolerite, probably in the form of a laccolithic intrusion. A few but conspicuous strange boulders lie here and there on the hill-top like ruins of great antiquity. Polished and scratched or grooved surfaces are seen everywhere. These differ in many respects from the curious grooves that have been occasionally noticed on the igneous intrusions in the South Staffordshire coalfield and elsewhere. The latter, for instance, are usually irregular and slightly wavy or curved, while the lines or grooves on the loose fragments of the dolerite of the Sha-yuan-ling are not only of frequent occurrence on the whole

[1] Coaz, *Die Lawinen in den Schweizer Alpen*, Berne, 1881. Heim, *Die Gletscherlawine an der Altels am 11 September, 1895*, Zurich, 1895 (N. N. G. Z., 1896), pp. 11–17. Pasquier, *L'Avalanche de l'Altels le 11 Septembre, 1895*, Neuenburg, 1896.

[2] *China*, vol. iv, p. 214, pl. xliv, figs. 4, 5.

surface of the hill, but are quite straight and sharply defined. Clearly, then, they are in no way comparable.

It should, however, be mentioned that some of the fragments possess peculiar smooth and striated surfaces. These can be easily distinguished in the field from the polished and scratched surfaces by the fact that they are either slightly warped, often with a glossy brown incrustation, or exhibit rudely parallel wrinkles with a projecting rim attached to the edges or the corners. Fragments having this kind of surface look as if they had been partially moulded in a more or less plastic condition, or, what is more likely, had been carved out by a neighbouring fragment shifted under intense pressure. Such pressure, it is not difficult to imagine, might have been set up by differential expansion of the rock-mass

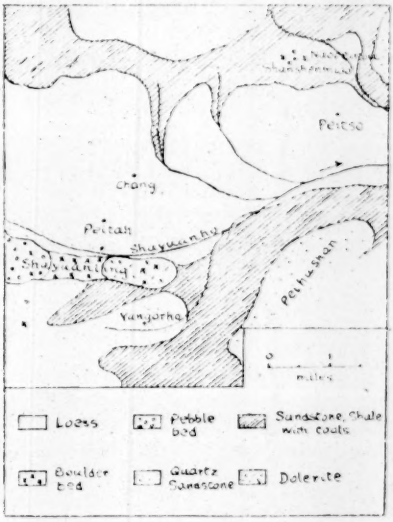

FIG. 3.—Geological map of the Sha-yuan-ling district.

due to a sudden rise of temperature, or might well be exerted by a great mass of ice that under special circumstances could have concentrated its pressure on a number of crumbled rock-fragments. When we reflect over the profound contortion of well-laminated rocks produced by ice-action, this apparently wild assumption seems plausibly to claim some respect.

Judging from the occurrence of huge blocks of the hard quartz sandstone 1·5 miles south-west of the Sha-yuan-ling and from the north-easterly axial trend of the anticline already mentioned, it seemed probable that the hypothetical glacier might have taken advantage of the denuded anticline and directed its course towards the north-east. If this be the case, we should expect to find traces

of glaciation in the hills further north-east. This is borne out by fact.

About 3·5 miles north-east of Sha-yuan-ling a roundish knoll rises above the loess plain with a small temple, the Shan-shien-miau, standing on its top as a conspicuous landmark. A small valley runs along the northern foot of the hill in a south-easterly direction. At Nau-pei-kou, a few hundred yards north-east of the Sha-shien-miau, and about 1 mile north of the Pei-tso village, the trend of the valley is slightly deviated by a hill-spur projecting from the south. Here, bedded green and buff sandstones, belonging to the uppermost part of the coal-bearing series, are well exposed. In the bottom of the valley parallel grooves are seen on the surface of an extremely hard sandstone in situ. The surface appears to be on the whole horizontal but locally undulatory, showing decisively that it has been planed or abraded by some powerful agent. All of the grooves run north-east, except for a minor set which cuts the former at a very small angle.

The sandstones dip regularly south-east. No sign whatsoever can be detected pointing to the existence of a thrust or a fault. One of the abraded beds in the bottom of the valley exhibits a partially striated, concave surface with its striated part inclined towards the north-east; while the unstriated part, namely, the north-eastern part, tends to curve upward towards its north-eastern edge. Such a state of things could not possibly have been brought about by a dislocation of the bedded rocks, nor could it be attributed to the hypothetical expansion and consequent slip of an overlying stratum.

It may be reasonably questioned that if a glacier did actually occupy the valley during a recent geological time, how could it have left traces of its movement across the valley instead of along it, since the latter would be a far more natural course? To answer this question we need to know the nature of the valley and the topography of the surrounding country. The valley, or more properly the ravine, is only of very small size, being 20 to 30 feet wide at the bottom and not much deeper than 200 feet from the bottom to the top of the hill on the south. Therefore an ice-sheet of moderate thickness could have indiscriminately buried the whole area, and made its movement quite independent of the local irregularities of the floor. The occurrence of strange blocks and fragments of rocks on the top of the hill of the Shan-shien-miau, which stands much higher than the hill just referred to, and the heavy abrasion that the bedded rocks of Nau-pei-kou must have gone through are facts which combine to demonstrate the considerable thickness of the ice.

The boulder-bed of the Sha-yuan-ling, as already mentioned, is quite loose and in a way conformable with the overlying loess. A priori it is a geologically recent deposit. If the quartzite pebbles occurring in the upper part of the boulder-bed be genetically

connected with the so-called pebble-bed of northern Honan, then the age-problem can be at once solved; for we know definitely that the pebble-bed is everywhere else immediately overlain by the loess. Meanwhile, let us turn to the fossil evidence. Cases are known that the so-called *Pterophyllum carbonarium* Schenk associates with forms closely related to *Nilssonia*. This would mean that the upper part of the coal-bearing series either belongs to the Permo-Mesozoic or even entirely to post-Palæozoic. In any case the possibility of the boulder-bed belonging to the Permo-Carboniferous can be absolutely excluded. It might be, however, urged that the ice-marked rock-fragments could have been originally produced in some period earlier than the late Tertiary or early Pleistocene, and became re-arranged before the dawn of loess time. But if this be the case, how could the gigantic blocks of rocks, entirely unknown in the neighbourhood, be brought to their present resting place? How can the unstratified state of the deposit be explained if the material was wholly transported by water? Why are some of the fine striæ and most of the sharp edges of the boulders or fragments remarkably well preserved? It would be extremely difficult, if not impossible, to find a satisfactory explanation save on the basis of recent glaciation.

(2) During a reconnaisance in the Tatung Basin, Northern Shan-si, I was struck above the village of Kou-tsuen (about latitude 40° 5′ N., longitude 113° 15′ E.) by a U-shaped valley which extends a little less than 10 miles in a west-east direction, and shows a wonderfully uniform width throughout its entire length. In the valley there occur strange boulders consisting of gneiss, schists, basalt, and many other kinds of igneous rocks. They are not derived from the hills on both sides of the valley, nor from the watershed that separates this valley from the broad expanse of lowland which forms the western part of the basin; for all these hills are composed of piled-up horizontal or nearly horizontal strata of Jurassic sandstones, which on the top of the watershed are covered by the loess and near the entrance of the valley are replaced by the Palæozoic coal-bearing series and the Sinian Limestone. Thus it is beyond doubt that the boulders are not of local origin. As there appears no sign that the present valley had once extended across the watershed, the boulders could not have been transported by a pre-existing river whose source might have extended far back into the mountains on the west of the Tatung Basin.

The side of the valley is sometimes so steep, particularly in its lower part, that it almost merges into a cliff, assuming the shape of a snubbed hill-spur. Near the base of one of such cliffs a block of dislodged sandstone was found, which exhibits coarse parallel furrows on one of its surfaces. The bottom of the valley is filled up by stratified but hardly consolidated rock-debris, attaining a thickness of more than 20 feet in many places where the river erosion has gone so far as to permit measurement. Above this deposit

there is as a rule a mantle of loess. On the bottom of the valley several sub-angular, half-polished and scratched boulders, or pebbles, were found at different localities (Pl. II, Figs. 3, 4). They appear to be closely associated with the detritus deposit. As far as I am able to judge, no distinction can be made between these and any of the typical striated boulders found in the Boulder-clay. It is inconceivable that they are of different origin.

If the facts brought forward here amount to positive evidence of recent glaciation, as they appear to the writer, we may proceed to consider what data are available to show that these are not merely local phenomena. In the case of southern Chi-li the mean altitude of the glaciated area cannot be much more than 300 feet above the vast alluvial plain of N.E. China, and no enormously high mountains could have existed in its neighbourhood which might have let down boulders from their ice-caps in late Tertiary time, and have since been planed away or subsided. Moreover, the quartzite pebbles or the "Egg-stones" already referred to, are known to occur in multitudes on many a hill-top east of the Tai-hang range; and they are everywhere immediately overlain by the Hwangtu or the loess. Seeing that these quartz pebbles associate with striated boulders in the Sha-yuan-ling, it does not seem improbable that they maintain elsewhere a similar relation with the glacial deposit. As regards the possibility of local glaciation due to great elevation of land, the argument used to dispose of the case of southern Chi-li can be likewise appropriately applied to the case of the Tatung Basin, though it should be mentioned that the mean altitude here is much greater, being 3,600 feet above the plain of Peking. Nevertheless, unless there had been a profound change of climatic conditions, including at least a general lowering of temperature, glaciation would have been obviously impossible.

In many parts of N. China, particularly on the eastern side of the Tai-hang Range and its north-eastern continuation, the loess is underlain by a detritus deposit, fairly uniform in character. From its constant association with the loess and from its mixed appearance it may be interpreted as the product of torrential rain which might have foreshadowed the advent of desert conditions on the one hand, but on the other there is no reason why it cannot be a glacio-fluviatile deposit. The wide distribution of this deposit is a fact which rather tends to show its glacial origin. While there is no further confirmation to decide this case, it is reassuring to note the reported occurrence of woolly rhinoceros in the Yang-tze Valley. The latter fact, when established, would imply wide prevalence of low temperatures on the eastern Asiatic continent as the Tertiary period drew near its end.

In the light of these facts one cannot but admire the keen insight of James Geikie, who, basing his opinion on scattered observations between Si-ngan and Toong-kwan, Southern Shen-si, the north-east corner of Shan-tung, and Mongolia, stated nearly half a century ago,

Striated Pebbles from Northern China.

To face p. 21.

that there once existed ice-masses that left their load and tracks all over N. China.[1] Had this celebrated author been able to collect more evidence, and so to present his case in a more forcible way than a mere passing remark, it would have drawn, as it fully deserves, much more attention from the scientific public; and would have given impetus at least to those keen observers that have conducted many a fruitful scientific exploration into various parts of the country since Richthofen's time. But when the author remarks that the Chinese ice-sheets descended from the Great Himalayan Range, his inference seems to have been extended a little too far; for the author himself mentions no fact in support of such a hypothesis, nor are we able to gather any evidence pointing to that effect if we turn to the reports contributed by many brilliant explorers like Bogdanovitch, Rovorovsky, Obrutchov, Loczy, and others. It may be safely said that we are as yet thoroughly ignorant as to the origin and the movement of the Chinese ice-sheets or ice-rivers. Any attempt made with the object of throwing light upon this subject must, for the present, be directed towards the field.

EXPLANATION OF PLATE II.

FIG. 1.—A striated pebble found in the Sha-ho-hsien Coalfield, Chi-li N. China. Max. length and width, 16 × 10 cm.

FIG. 2.—A portion of a partially striated rock-surface at Nau-pei-Kou, Chi-li, N. China. Max. length and width, 42 × 17 cm.

FIG. 3.—A striated pebble found in the Tatung Basin, N. China. Max. length and width, 23 × 17 cm.

FIG. 4.—A striated pebble found in the Tatung Basin, N. China. Max. length and width, 34 × 14 cm.

On some New Species from the Lower Carboniferous of Ballycastle, Co. Antrim.

By LOUIS B. SMYTH, M.A., Sc.B., Lecturer in Palæontology in the University of Dublin.

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(PLATE III.)

IN the course of collecting in the Ballycastle coalfield, the species described in this note were obtained. Details of the associated fauna will be found in the forthcoming memoir of the Geological Survey of Ireland relating to the district. It is only necessary to mention here that the beds from which the present material comes are, in the memoir, referred to a D_2 horizon.

Cypricardella nuculoides, sp. nov. (Plate III, Figs. 1*a–c* and 2.)

The form and dimensions of this shell are sufficiently shown by the figures. It will be noticed that there is no oblique ridge from the beak to the postero-inferior angle, and the posterior end is not truncate. The ornament consists of sharp, raised, concentric ridges. A left valve with hinge exposed (Fig. 2) shows two cardinal teeth,

[1] *The Great Ice Age*, p. 402.

with a triangular socket between them, and a long posterior-lateral tooth, with a groove above it.

Holotype.—A specimen having the two valves attached, in the collection of the Geological Survey of Ireland.

Locality.—Common in the shales immediately overlying the main limestone at North Star Colliery, 1½ miles east of Ballycastle.

This may possibly be the species figured by W. Hind (Mon. Brit. Carb. Lamell., pl. xxxix, fig. 6) as *C. parallela* Phill. ? which he suggested might be a sport.

Protoschizodus brevifrons, sp. nov. (Plate III, Figs. 3*a–c*.)

This species agrees with De Koninck's genus in external features. No specimen was found showing internal structure, but by rubbing down, from the right side, a left valve embedded in matrix, the two teeth characteristic of the genus were proved.

The following characteristics distinguish the present species :—

1. Very short anterior end.
2. Very pointed, and rather produced, posterior end.
3. Postero-dorsal region, behind the oblique ridge, flattened at right angles to the plane of the valve margins.
4. Postero-dorsal margin scarcely at all compressed, so that only a very slightly elevated ridge is formed. This feature is not clear from Fig. 3*a*. Fig. 3*c* expresses it better.

Holotype.—A specimen having the two valves attached, in the collection of the Geological Survey of Ireland.

Localities.—Common in the shales immediately overlying the main limestone at North Star Colliery, 1½ miles east of Ballycastle. The type came from this locality. Also occurs in red shales of the same horizon at Murlough Bay, on the east side of Fair Head.

Chonetes elegans, sp. nov. (Plate III, Figs. 4*a–d*.)

A small *Chonetes* is abundant at Ballycastle, which is easily distinguished from any species hitherto named. In the hope that it may prove to be of zonal value it is here given a name and described.

Description.—Length of largest specimen 15·5 mm., width 22·5 mm. Average ratio of length to width $\frac{2}{3}$. Concavo-convex, regularly curved from umbo to anterior margin along median plane. Average convexity of pedicle valve in larger specimens about 0·36 of length. Widest part a few millimetres below hinge-line. About sixty specimens in seventy-four showed a more or less distinct, shallow, ventral sulcus.

Costae fine, sharp, about twenty-five in 5 mm. on the middle of the pedicle valve. They increase almost exclusively by intercalation on the pedicle valve; by forking on the brachial valve. Concentric ornament extremely fine.

Cardinal spines usually eight on each side of umbo. Greatest width of ventral area about 1 mm., of dorsal 0·5 mm. Strongly arched

deltidium. Chilidium of two triangular flaps resting against the quadrifid cardinal process.

The interior of the brachial valve shows a rather characteristic pair of radial ridges (Pl. III, Fig. 4*c*, and Text-fig. 1, A), beside the median ridge (M), which marks presumably the inner margins of the anterior adductor scars. The brachial ridges (B) are only well marked at their proximal extremities.

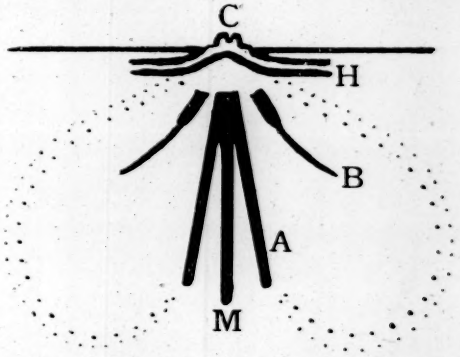


FIG. 1.—Diagram to show position of ridges in the brachial valve of *Chonetes elegans*, sp. nov. C, cardinal process; H, hinge plate; B, brachial ridge; A, ridge marking inner margin of adductor scar; M, median ridge.

Holotype.—A specimen with only the exterior of the pedicle valve free of matrix, in the collection of the Geological Survey of Ireland.

Locality.—Very abundant in the shales associated with the main limestone at North Star Colliery, 1½ miles east of Ballycastle.

Comparisons.—This species agrees very well with pl. xlvii, fig. 12, of Davidson's Mon. Brit. Carb. Brach., except in the shape of the cardinal extremities, which is more like that of fig. 16 of the same plate.

Specimens recorded as *Ch. laguessiana* from the Lower Limestone of Scotland (Scot. Surv. Coll. 213),[1] agree with the present form in all respects, except the proportion showing a ventral sulcus, which was 16 in 32.

The *Ch.* cf. *hardrensis* of the Acre Limestone (D_2), Northumberland, is again practically the same. In twelve specimens[2] the only differences from the Ballycastle form were that only two had any trace of a ventral sulcus, and the number of cardinal spines was usually six or seven on each side, only one having eight.

A somewhat similar, if not identical, form is figured and briefly described by Vaughan[3] from D_{2-3} of Gower.

[1] I was enabled to inspect these through the kindness of Dr. G. W. Lee.

[2] Kindly lent me by Dr. Stanley Smith.

[3] Dixon and Vaughan, "The Carboniferous Succession in Gower": *Q.J.G.S.*, vol. lxvii, 1911, p. 561, and pl. xli, figs. 3*a*, 3*b*.

Ch. laguessiana De Kon.[1] is smaller, has its greatest width at the cardinal edge, has only four spines on each side of the umbo, and its costae are " à peine visibles à l'œil nu ".

Ch. dalmaniana De Kon.[2] differs in its greater size, more numerous spines, and acute cardinal angles.

Tabulipora serrata, sp. nov. (Pl. III, Figs. 5*a–b*.)

Solid, cylindrical, branching zoarium, 3 to 9 mm. thick. Agrees most closely with *T. multitabulata* G. W. Lee, but differs from that species as follows:—

1. Walls of peripheral part seldom as thick as zoœcial diameter.
2. Moniliform structure frequent.
3. Stereoplasm banked up against the distal faces of the tabulæ, giving them in longitudinal median section the appearance of thorns, or saw-teeth. This suggested the specific name.
4. Tabulæ generally convex towards the mouths of the zoœcia.
5. Acanthopores not differentiated into two sets.

Holotype.—A specimen (wholly used up in making three slices—radial, tangential, and transverse) on a micro-slide in the collection of the Geological Survey of Ireland.

Locality.—Common in the main limestone and associated shales at North Star Colliery, 1½ miles east of Ballycastle.

?Carcinophyllum sp. (Plate III, Figs. 6*a–b*.)

As only one imperfect specimen of this species was found I have not given it a name. It is a very small coral, with " roots " arising in whorls. After being photographed it was cut into six transverse slices. Fig. 6*b* is a drawing of section 4, which passes through one of the " roots ".

EXPLANATION OF PLATE III.

NEW SPECIES FROM D_2 OF BALLYCASTLE.

Figs. 4*a–d* and 6*a* are from photographs; the remainder are from camera lucida drawings.

FIG. 1.—*Cypricardella nuculoides*, sp. nov. Type-specimen. × 1·5. 1*a*, right side; 1*b*, anterior view; 1*c*, dorsal view.

,, 2.—*Cypricardella nuculoides*, sp. nov. Hinge of left valve of another specimen. × 1·5.

,, 3.—*Protoschizodus brevifrons*, sp. nov. Type specimen. × 1·5. 3*a*, left side; 3*b*, outline of posterior view; 3*c*, dorsal view.

,, 4.—*Chonetes elegans*, sp. nov. × 1·2. 4*a*, pedicle valve, showing sulcus; type specimen. 4*b*, pedicle valve of another specimen; sulcus scarcely developed. 4*c*, interior of brachial valve of a third specimen. 4*d*, interior of brachial valve of a fourth specimen. Note, the left-hand member of the pair of ridges (M in Text-fig. 1) close to median ridge is, in this case, extremely short.

,, 5.—*Tabulipora serrata*, sp. nov. Type specimen. × 17·5. 5*a*, portion of radial section, showing two acanthopores. 5*b*, portion of tangential section.

,, 6.—*?Carcinophyllum*, sp. 6*a*, general view, showing whorls of " roots ". × 1·7. 6*b*, tranverse section along plane 4 of previous figure, passing through one of the " roots ". × 3·2.

[1] *Recherches sur les Animaux Fossiles*, L. De Koninck, Liége, 1847, p. 198.
[2] Loc. cit., p. 193.

1a

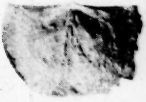
1b

1c

2

3a

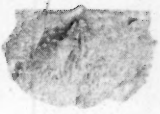
3c



4c

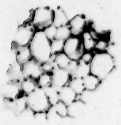
4a

4b



4d

5a



5b

6a

4

6b

NEW SPECIES FROM D_2 OF BALLYCASTLE, ANTRIM

[To face p. 71.

The English "Eskers"—their Structure and Distribution.

By J. W. Gregory, D.Sc., F.R.S.

THE terms "kame" and "esker" have been applied in England to various mounds and ridges of sand and gravel. For some, such as those in South-east Essex [1] either name is inappropriate, since they are not glacial deposits but are tide-formed banks of shelly sand. Most of the described English kames and eskers are clearly related to glacial formations, and their distribution and structure throw light on the later stages of British glaciation.

The following terms are used in accordance with definitions adopted in earlier papers [2]: (1) Drumlins, mounds of boulder clay; (2) Osar, fluvioglacial ridges deposited as receding river deltas and typically with seasonal banding; (3) kames, ridges or mounds of sand or gravel deposited by water on the margins of an ice sheet; they include three varieties: (*a*) fluvioglacial; (*b*) glacieluvial; (*c*) residual kames, those due to the denudation of thick banks of glacial sand and gravel. Many residual ridges and mounds have been described as kames, and some of them may be entitled to the name as being due to an original thickening in a bed of gravel; but as it may be impossible to distinguish primary kames in an advanced stage of denudation from the residues of beds of gravel the application of the term kame to such cases is undesirable, unless there is a strong probability of their formation as marginal drift hills.

The term esker has been applied to all varieties of Irish hills of glacial sands and gravels, and has been used for English drifts in a similarly comprehensive non-genetic sense.

The following account of the English "eskers" is intended to show which of them are osar and which are kames, and to consider their distribution in reference to English glaciation.

I. Northumberland.

The kames of Northumberland may be divided into three groups. The first group is in the N.W. part of the county near Coldstream, and includes the kame at Wark Castle beside the Tweed and that at Pallinsburn, N. of Flodden.

1. *Wark and Pallinsburn.*—The best-marked kame on the English bank of the Tweed is that at Wark. It has been described by P. Mearns.[3]

[1] Holmes, *Geol. in Field*, 1909, p. 57.

[2] *Geogr. Journ.*, vol. xl, 1912, pp. 169–75; *Trans. Geol. Soc. Glasgow*, vol. xiv, 1912, pp. 199–218; *Phil. Trans.*, ser. B, vol. ccx, 1920, pp. 115–51; *Scott. Geogr. Mag.*, vol. xxxi, 1915, pp. 465–76.

[3] *Hist. Berwick. Field Club*, v, 1886, pp. 224–31. *Mem. Geol. Surv.*, 110 S.W., 1895, pp. 76, 77; *Geol. Assoc., Geol. in Field*, 1910, p. 695.

Its geological history is best considered in connexion with the Scottish kames, so only a brief statement regarding it is here made. It is a fairly straight ridge, and of a total length of about 1,400 yards, though broken by two considerable gaps; the best preserved part is about 400 yards long and extends from S. of Douglas' Tomb on the W. to the E. end of the village. The W. end is a low bank on

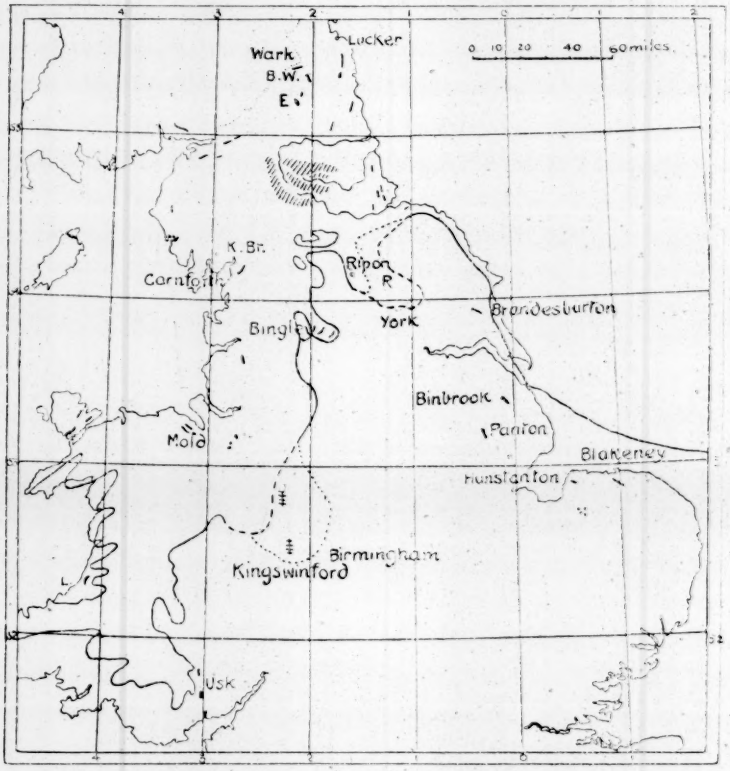


FIG. 1.—Distribution of English Kames and Osar. ‡ Osar. — Kames. The shaded patches in W. Durham are areas, which, according to Dr. Dwerryhouse, were not ice-covered. — · — · Carvill Lewis' line of terminal moraine; it is shown broken where his own later work showed that it required modification. .... The dotted line indicates the probable ice margin in those districts. B.W., Bowmont Water. E., Elsdon. K.Br., Kellet Bridge. L., Llanrhystyd. R. Raskelf.

the S. side of the road: the base of the kame gravel is seen at each end of this bank, while in the middle is exposed the underlying sandy boulder clay with many striated stones. The kame material is best shown in the gravel-pit W. of the ruined Castle and in the gap through the kame known as Gilly's Neck, 280 yards W. of the Castle and just S. of Douglas' Tomb. The material is a sandy

gravel with all the pebbles well water-worn. I saw no striated stone in the main mass of the kame, but in the lowest layer, just E. of Gilly's Neck, are some boulders with faint traces of striæ. The kame rises to the level of about 125 feet O.D. and about 60 feet above the level of the Tweed. Mearns, who explains the kame as due to "currents in a former sea" (op. cit., p. 231), describes the beds as stratified; but I saw no clear stratification, probably owing to the sections being now old and obscure.

This kame is probably part of the wide sheet of sand and gravel which to the S.E. and E. of Cornhill overlies the boulder clay and occurs at about the same level as this kame. This sheet is mainly derived by denudation from the boulder clay. The Wark kame is a bank of this gravel deposited on the floor of a valley cut in the boulder clay that filled the pre-glacial valley of the Tweed. The kame was left by the erosion of the present Tweed valley and of the dry branch of that valley between Wark and a high whale-backed drumlin to the S.

Pallinsburn Knowe (N. of the Cornhill road and W. of the village) has been described as a kame.[1] The hill pointed out to me at the village as the Knowe has the shape of a drumlin, and a section in a road cutting just E. of a lodge, exposes loam with a few boulders, and all of those examined were striated. At the time of my visit the hill was covered by wheat, so I could not traverse it or examine the gravel, which is described by Gunn[2] as well-rounded and coarse, with patches of dirty sand and clay.

2. *The Gravel Ridges of the Bowmont Water*—a tributary to the Glen River (7 miles S.W. of Coldstream)—have been described as forming conspicuous ridges.[3]

A long fish-back-like ridge of drift lies in the narrow valley of the Bowmont Water between Kilham and Kirknewton. The material of this drift is exposed beside the road E. of Kilham in a low ridge-like platform, of which the form is clearly due to denudation. The gravel is coarse and contains water-worn boulders; no striated stone was seen. This mass of drift appears to be a glacieluvial deposit that was laid down in front of the ice which filled the Kilham basin; the drift blocked up the outlet; a lake was formed, and its overflow excavated the gorge of the Bowmont Water and cut the gravel into ridges parallel to the valley. The form of these ridges is therefore secondary. Amongst the changes of river direction in this district was the temporary separation of the Bowmont Water from the Glen River by the formation of this glacieluvial dam.

3. *Coastal Series.*—The Lucker or Bradford Kame, the best developed kame in Northumberland, passes 2 miles W. of Bamburgh

[1] F. M. Norman, *Hist. Berwick. Field Club*, x, pt. iii, 1884, pp. 449-2. *Mem. Geol. Surv.*, 110 S.W., 1895, p. 74.

[2] *Mem. Geol. Surv.*, 110 S.W., p. 74.

[3] *Mem. Geol. Surv.*, 110 S.W., 1895, p. 78.

Castle and 1 mile E. of Lucker Station. It has been frequently mentioned or described.[1] Its N. end is at Spindlestone Hill, whence it extends S. beyond Newham Station; but it is not continuous throughout that length, for part of the hills along that line I regard as drumlins of sandy boulder clay. The kame is well shown on the road from Lucker Station to Bamburgh, and there lies at the W. foot of a series of drumlins; from them it is separated by a moss that represents an old pool, the overflow from which has cut a channel through the kame, showing a section 40 yards wide and 20 feet high; the steeper side faces E. The kame is slightly sinuous. Its material is a loamy gravel with angular, faceted pebbles and boulders, on some of which glacial striæ are distinct, though faint; its clayey nature is shown by the burrows on the kame there being those of moles, not of rabbits, which swarm on the sandy patches of the neighbouring drumlins. S. of the road the kame trends S.S.W. on a sinuous course, to the W. of the drumlin of Camp Hill, and a gravel pit in the kame W. of that hill shows faceted pebbles in loam. S.W. of Camp Hill, and separated from it by alluvium, is Ell Hill, where there are many overgrown shallow gravel pits; in the lower part of the deposits there boulders are scarce, but the upper part is much coarser. A fair sample of the pebbles contained Carboniferous limestone, 50 per cent; cherty limestone, 10 per cent; Carboniferous sandstone, 18 per cent; red grit, 6 per cent; basalt (the local whin), 10 per cent; dark-grey porphyrite, 2 per cent; red andesite, 4 per cent. The last two rocks have come from the W. from the Old Red Sandstone lavas near Wooler. S. of Ell Hill the kame ends against a long drumlin of sandy boulder clay that continues the line S. to Newham; sections of the material—a sandy loam free from pebbles and boulders—occur N. of Newham on the road to Hen Hill. On the lower ground S. of Newham the kame reappears and bends W. across the railway, S. of Newham Station. The kame lies at a lower level than the adjacent drumlins, which rise to the height of 195 feet at Golden Hill and 178 feet at Camp Hill.

This Lucker Kame consists of a loamy and not a sandy gravel. The sand used on the roads is brought from the seashore, which suggests that none is known along the kame. The pebbles are faceted. Tate[2] recorded striated boulders in the kame, and this report is quoted in the *Mem. Geol. Surv.*, 110 S.E., p. 109, as if unconfirmed. The presence of striated stones is also recorded by Lebour and a well-glaciated cobble from Ell Hill (now placed in the Hunterian Museum, Glasgow) confirms Tate's observation. This ridge, from its loamy base, faceted and occasionally striated

[1] Ramsay, *Phys. Geol. England and Wales*, 1894, 6th ed., p. 262; G. Tate, *Hist. Berwick. Field Club*, v, 1866, p. 239; G. A. Lebour, *Geol. Northumberland*, 1886, p. 21; *Geol. Assoc., Geol. in Field*, 1910, p. 695; *Mem. Geol. Surv.*, 110 S.E., 1900, pp. 108-9.

[2] *Hist. Berwick. Field Club*, v, p. 239.

stones, its irregular bedding and the nature of its longitudinal variations may be classed as a glacieluvial kame. Its chief curves are concave to the W.; that fact and the frequency of former pools between it and the drumlins to the E. indicate its formation along the E. margin of ice which flowed from the W. and abutted against the drumlins along the coast. According to Lebour (op. cit., p. 21) this kame consists of "marine deposits".

Buckland [1] has referred to the southern end of this kame at North Charlton as a tortuous bank of gravel and as supposed to be "an inexplicable work of art".

4. *S. Northumberland.*—H. Miller has remarked [2] the morainic character of some kames near Elsdon and Harbottle in the valley of the Coquet; they appear to consist of glacieluvial material. Widespread fluvioglacial sands and gravels occur in S.E. Northumberland; some of them, as at Eachwich and Dissington beside the Pont R., E. of Stamfordham, and those of the Newbiggin and Blanch Burns, appear from the description of Dr. J. A. Smythe [3] to form original kames; others form residual kames. Professor Marr has reminded me of the ridged form of those near Corbridge.[4]

II. Durham.

Similar in origin to the Lucker Kame appear to be the kames near the coast of Durham, including a circular mound of gravel at Betterlaw and a group of deposits at Sheraton, 5 miles W. by N. from Hartlepool. These deposits have been described by Dr. Trechmann [5] and by Dr. Woolacott.[6] The latter author gives full references to the literature. He concludes that they are marginal deposits along the W. margin of the Cheviot glacier, and are true kames. Trechmann has found in one of them a Scandinavian boulder—possibly derived from the North Sea boulder clay.

A kame has been identified at Durham by Carvill Lewis.[7] It has been re-examined by Dr. Trechmann and Dr. Woolacott, and the former says [8] that in their opinion its form is due to post-glacial fluvial erosion.

The formations described by Dwerryhouse [9] as esker-like ridges in the valleys of W. Durham, especially near Stainmoor and Lunedale and in the valley of the Tees above Barnard Castle, probably also owe their form to post-glacial denudation.

[1] *Proc. Geol. Soc.*, 1841, iii, p. 346.
[2] *Mem. Geol. Surv.*, 108 S.E., 1887, pp. 108–110.
[3] *Trans. Nat. Hist. Soc. Northumberland*, n.s. III, 1908, p. 83, and IV, 1910, p. 95.
[4] Cf. Lebour, op. cit., 1886, p. 25.
[5] *Q.J.G.S.*, lxxi, 1915, pp. 73–7, pl. viii.
[6] Geol. Mag., Vol. LVIII, 1921, p. 28.
[7] *Glac. Geol. Gt. Brit.*, 1894, p. 172.
[8] *Q.J.G.S.*, lxxi, 1915, p. 76.
[9] *Q.J.G.S.*, lviii, 1902, p. 575.

III. Yorkshire.

In Yorkshire esker-like formations are well developed at intervals near Carvill Lewis' line showing the moraine which he considered to mark the limits of the English land ice. In the Bingley-Ilkley-Shipley area the eskers belong to two series, a low level series on the floor of the Aire valley and a high level series on the moors between the Aire and Wharfe valleys.

1. *The Low Level Kames of the Aire Valley.*—Some of the most accessible of the low-level formations occur along the Aire valley, and may be seen from the Midland Railway. They have been briefly described by Green.[1] The drift mounds on the floor of the valley occur at intervals from between Steeton and Silsden, where a few small hummocks occur at the level of about 300 feet, past Bingley, where they form a band of gravel mounds across the valley, above and below Saltaire, to about half-way between Charlestown and Tong Park. The sections that I have seen in these gravels are poor. Just W. of the first lock W. of Saltaire, north of Wigglesworth's Engineering Works, the mounds consist of tumultuous gravels with many sandstone boulders 9 in. and some 2 feet in diameter. Some of the smaller boulders are of Carboniferous limestone. Pebbles of black chert are abundant. The constituents of the gravels are well rounded; a few of the boulders show faceted surfaces as if they had been glaciated, but I saw no striæ on them, nor evidence of transverse banding. The uppermost layer is crowded with boulders and large pebbles, probably by the removal of the lighter constituents during denudation.

Further down the Aire Valley a bank of fluvioglacial gravel, but with the pebbles more rolled and water-worn than those opposite Wigglesworth's, occurs on the N. side of the main road from Charlestown to Tong Park and just W. of a by-road going S. across the valley to Thackley. The bank projects as if it were the remains of a barrier across the valley. The gravel is exposed in a pit on the E. side of that by-road: the pebbles are mainly of Carboniferous sandstones and limestones.

Green applied the term esker to the Aire Valley mounds, while recognizing that their shapes were due to denudation and that they were the remnants of larger masses of gravel. Green suggested that they were formed as terminal moraines in which the material had been shot into water, therein spread out as bedded gravel, and subsequently denuded into mounds.[2] This explanation seems consistent with all the available evidence. As they were water-deposited and were not directly dumped from the ice, they are not moraines; they were formed at intervals along the valley as aqueous

[1] *Geol. Yorks. Coalfield*, 1878, pp. 775, 779, and 782; *Mem. Geol. Surv.*, 92 S.E., 1879, p. 12.

[2] Carvill Lewis has doubtfully referred to the mounds at Bingley as part of his terminal moraine, which he also suggests was possibly at Skipton (op. cit., pp. 193, 239.)

deposits near the margin of a retreating glacier, and may therefore be regarded as fluvioglacial kames.

2. *Reported High Level Eskers—the Lanshaw Delves.*—Of the high-level "eskers" of this part of Yorkshire, the most often mentioned has been the Lanshaw Delves, which is situated on the N.E. slope of Rombald's Moor, 1½ miles S.S.E. from Ilkley, at the level of about 1,180–1,200 feet on the S. side of the Wharfe Valley. It is a bank about 650 yards long, 25 yards wide at the W. end, and 50 yards wide at the E. end; the height is 8 feet at the W., and 15 feet at the E. end; the trend is a little S. of E.; the S. front is the straighter and higher. The summit of the Delves is irregular and hummocky, the depressions sometimes giving it the character of a triple ridge. It has been referred to as a high level esker by Green.[1] Carvill Lewis has given the best account of it.[2] He described it as moraine, and regarded it as part of a long lateral moraine. It consists of sandy loam, with many angular blocks of Millstone Grit similar to those strewn over the adjacent moor. Some of the boulders are 4 feet in diameter; many are 2 feet long. They are irregular in shape, and none shows glaciated forms or striæ. The smaller pebbles include vein quartz, and jagged fragments of black chert; and all of these may have been derived from the Millstone Grit. A few well-rounded cobbles may have been derived from a local stream. The occurrence of angular flakes of grit, some of them many square inches in area and a quarter of an inch thick, show that the material was not transported by rivers or these pieces must have been broken. The boulders are sometimes crowded in piles, but they show no arrangement in bands across the Delves. The bank shows no signs of formation as an ordinary aqueous or fluvioglacial deposit. It is a morainic bank formed along the margin of a sheet of snow and ice that filled the depression in which lies Lanshaw Dam. The moor rises to the height of 1,320 further W., and to 1,250 feet at 800 yards S. of the Delves. The depression between the summit and the Delves faced N.E. and was probably filled with a sheet of snow and ice. The local blocks of Millstone Grit were carried to its edge, but the movement was insufficient to give them glaciated forms or striæ. The Delves are the remains of a moraine on the margin of an embryo corrie glacier.

According to Green the Delves can be traced for three miles across the moor. Some coarse gravel occurs further E., a little S. of the farm known as Gaping Goose on Hawkshaw Moor; but I saw no evidence of its continuity with the Delves. Carvill Lewis (op. cit., p. 243) records information from some shepherds about structures known as the "Great and Little Skirtfull of Stones" and "Long Ridging", which he suggested might be similar in origin.

[1] *Geol. Yorks. Coalfield*, 1878, p. 779; *Mem. Geol. Surv.*, 92 S.E., 1879, p. 12.

[2] Loc. cit., 1894, pp. 34, 243. It has been identified as a prehistoric earthwork.

The high-level eskers S. of Ilkley are said in the Survey Memoir [1] to rest partly on boulder clay, but I saw nothing to confirm this statement regarding the Lanshaw Delves or any erratics, boulder clay or other trace on the moor of any general glaciation of the district. The surface is littered with blocks of grit formed by weathering in situ. Even at the level of about 600 feet in a quarry at Eldwick, on the southern side of the moor, the deep decomposition of the sandstones indicates that there had been no glaciation at that locality. My observations agree with the generally accepted view that the hills in this district have not been covered by a general ice sheet, and that the only extraneous ice in this part of the Aire valley lay on its floor.

3. *Eskers in N. Yorkshire and near York.*—The interval between the Bingley Kames and those of S. Durham is partially filled by a few recorded esker formations including the "Roman Ridge" near Lendrick Farm, W. of Ripon, which trends N.W.–S.E.[2]; Cowper Reed [3] refers to it as "an esker-like ridge".

The formation in Yorkshire which, judging from the drift maps, appears the most osar-like is a band of sand and gravel that extends from York S. to Escrick, and has been identified as an esker by Professor Kendall.[4] Two curved bands of glacial sands and gravels occur in this part of Yorkshire. The northern band (Sh. 93, N.E.) passes through York N.E. to Helmsley and then N. and N.W. past Sheriff Hutton and Whenby. It has been described as the York moraine. A second curved band of boulder clay capped in places by sand and gravel is marked on the Geol. Survey map (Sh. 93, S.E.) passing 5 miles S. of York through Catton to Escrick and Stillingfleet (35 feet). It has been described by Professor P. F. Kendall [5] as a southern but probably younger moraine. Dr. Cowper Reed [6] refers to these bands as having been "considered by some geologists", as moraines. Professor Bonney [7] has discussed that view and rejected it.

On the view that the formations at York and Escrick are moraines, the position of the connecting band through Fulford to Escrick is suggestively osar-like. The intimate structure of the glacial drifts at York is described in the memoirs by J. F. Clark [8] who favours their deposition by floating ice, and Fox Strangways.[9] H. F. Parsons [10] has described sections in the Escrick drift. Otherwise the published information deals rather with the distribution of the drifts than with their composition and structure. I have recently

[1] 92 S.E., 1879, p. 12.
[2] *Mem. Geol. Surv.*, 96 N.W. and S.W., 1886, p. 55.
[3] *Geol. Riv. E. Yorkshire*, 1901, p. 17.
[4] *Proc. Yorks. Geol. and P. Soc.*, xii, 1893, p. 311.
[5] Ibid.
[6] *Geol. Rivers, E. Yorks.*, 1901, p. 17.
[7] *Presid. Addr. Brit. Assoc., Rep. Brit. Assoc.*, 1910, p. 26.
[8] *Proc. Yorks. Geol. and Poly. Soc.*, N.S., vii, pp. 421–39, pl. xxiii.
[9] *Mem. Geol. Surv.*, 93 N.E., 1884, pp. 28–30.
[10] *Proc. Yorks. Geol. and Poly. Soc.*, vi, 1878, pp. 214–38.

revisited the district to reconsider the impressions of previous visits.

The main road from York to Selby traverses the Fulford–Escrick band. The pits show gravel with waterworn boulders of Carboniferous rocks and pebbles of vein quartz, black chert, purple quartzite, and some green felspar-porphyry similar to that of the Lake District. Some of the boulders show flattened surfaces, but I saw none with glacial striæ. The gravel shows no osar-like cross banding. The freshest section seen on my last visit exposed six feet of horizontally bedded sands, interbedded with four layers of gravel. In some of the pits the predominant constituent is sand.

The material is typical fluvioglacial sand and gravel; it is part of a thin sheet and does not form a conspicuous ridge. The slopes are very gentle. Thus the road from Deighton Grove towards Wheldrake starts at the height of 35 feet O.D.; and the variations from that level recorded by the 6 in. map are as follows: At 700 feet + 3 feet; at 2,800 feet + 6 feet; at 5,600 feet, at Pool Bridge, − 9 feet; the road rises from this stream to − 2 feet. West of the York–Escrick road the land sinks in a gradual slope to the Ouse, which there flows at the level of 26 feet O.D., so that the descent is only from 10 to 20 feet. There seems accordingly no evidence either from internal structure or surface relief to refer the Fulford–Escrick band to the class of osar. It is one of several remnants of a sheet of gravel, the widespread range of which is indicated by the patches at Naburn and elsewhere, and by those marked on the Geological Survey drift maps by blue dots.

The band of sand, gravel, and boulder clay between Escrick and Wheldrake, which has been identified as the outer moraine, though somewhat more conspicuous than that from Fulford to Escrick, is a low, broad rise. Its height is about 30 feet above the adjacent plain; its slopes are gentle and it shows neither the humpiness characteristic of moraines, nor the steep sides of kames. I saw on it no large erratics. It appears to be a rise left by denudation. This view agrees with that of Professor Bonney, who, in his Presidential Address to the British Association (*Rep. Brit. Assoc.*, 1910, p. 26), concludes that "the so-called moraines near York . . . do not, in my opinion, show any important difference in outline from ordinary hills of sands and gravels, and their materials are wholly unlike those of any indubitable moraines that I have either seen or studied in photographs".

The bands of gravel between Fulford and Escrick and between Escrick and Wheldrake do not belong to the category of kames or osar.

4. *E. and S.E. Yorkshire.*—An "esker-like" ridge, resting on the Upper Boulder Clay in Stanghow Moor, Eskdale,[1] occurs on the flanks of the Cleveland Hills. Better developed eskers have been

[1] *Mem. Geol. Surv.*, 104 S.W., S.E., 1888, p. 67.

described in Holderness.[1] The best-known example is at Brandesburton, E. of Beverley, and outside of Carvill Lewis' line of E. Yorkshire terminal moraine. It contains marine shells. The course and form of this ridge is well shown on the 6 in. map, Yorks, East Riding, 196 N.E. It is about 2 miles long, and includes Barff Hill, Coneygarth Hill, and Gildholm Hill. I have not visited it; but its position suggests its origin as a kame marginal to the North Sea ice. A more detailed account of this formation is desirable.

IV. Lincolnshire.

Eskers have been described by Sir A. Strahan at two localities in E. Lincolnshire.[2] Near Binbrook Walk House, 6 miles N.W. of Louth, are three patches of gravel, which in one pit is cemented to conglomerate and breccia, in another it occurs as loose stratified gravel, mainly of rolled flints; the deposit occurs in a Chalk valley.

The other esker is S. of Panton Railway Station, 12 miles E.N.E. of Lincoln. According to Sir A. Strahan, its gravels are probably older than the Chalky Boulder Clay, and it formed a ridge trending N. and S., which has been cut through by the stream that flows from Market Stainton to Wragby.

The part of the ridge S. of the stream is the largest; it has, when seen from the W., a flat-topped sky-line. The material is exposed in a pit 20 feet deep and about 15 acres in area. Erratics, one of coarse grit 3 by $2\frac{1}{2}$ by $1\frac{1}{2}$ feet, occur on the road which crosses the S. end of the ridge. The section at the N.W. end of the pit shows at the top contorted flint gravel with pockets of sand and loam; below this layer is sand; at the bottom is a flint gravel with a loamy base and cobbles of porphyritic basalt and cherty grit. At the S. end of the pit the lowest bed is a white sand. The sides of the pit show great variations in the structure of the beds; but the main bedding is horizontal, not inclined, and the succession of the layers is not periodic. The succession is from white sands at the base, through gravel with a loamy base, and bedded loams, to contorted gravel and sand at the top. This represents a marked change in the conditions of the deposit, but I saw no indications of the seasonal banding or of the regular repetition of sequence characteristic of osar. This "esker" is a dissected fluvioglacial kame which was probably formed as interglacial gravel by wash from ice to the E.

V. Norfolk.

1. *Gravel Mounds of S.W. Norfolk.*—In Norfolk are widespread glacial gravels, some of which have been described as eskers, as by Mr. T. V. Holmes (Geol. Mag., 1883, p. 441), who, however, uses the term also for non-glacial deposits as he applies it to gravels in the tropical coasts of Peru. The term "esker" was apparently first

[1] J. Phillips, *Rivers, etc., Yorks.*, 1853, p. 124; *Mem. Geol. Surv.*, 93 S.E., 1886, p. 33; *Geol. Holderness*, 1885, pp. 51–3.

[2] *Mem. Geol. Surv.*, 83, 1888, pp. 124–5.

suggested in Norfolk[1] for a curved series of mounds at Congham Common, W. of Great Massingham, 8 miles E.N.E. of King's Lynn. Approaching the Congham mounds from the W., they at first appear esker-like. The main gravel pit shows the following section: Soil, crowded with angular flints with many frost-flakes, some of which have been "eolithically" chipped by a soil-cap movement; sand with subangular flints, flakes of flint, occasional round sandstone boulders, the largest 16 inches in diameter, and pebbles of carstone (probably derived from the N.W.).

I saw no striated stone. The most striking feature of this material is its angularity. The deposit lies in a typical dry Chalk valley, and is the remains of a sheet that once covered the floor and was formed by wash from the Chalk downs on both sides. Subsequently the valley has been deepened by cutting into this gravel, and the sinuous front due to this denudation has produced the esker-like aspect.

In the next valley to the south, about $1\frac{1}{2}$ miles S.S.W. of Great Massingham, are two wooded banks of sand and gravel, a little above the floor of the valley. They are doubtless the remnant of a bed of gravel most of which has been removed in the deepening of the valley.

Mr. Whitaker[2] has described the Bartholomew Hills, $2\frac{1}{2}$ miles N. of Swaffham, as esker-like and also other patches of gravels, including those W. of Massingham and on Grimston Heath further north. They have been described by Whitaker from notes by C. E. Hawkins and H. B. Woodward.[3] I have visited some of the occurrences, which from the map and descriptions seemed most esker-like; they appear to be remains of a widespread sheet of gravel, and to owe their occasional linear arrangement to the accidents of denudation.

2. *Hunstanton.*—Mr. Harmer has referred[4] to the striking absence of esker formations from East Anglia. The one exception that he admits is the "Hunstanton Esker", which is locally known as the Ringstead sand-hills. It is situated in a tributary to a dry Chalk valley, known as Ringstead Downs, about half a mile W. of Ringstead St. Peter, and about $1\frac{3}{4}$ miles E.S.E. of Hunstanton Railway Station. It has been described by Whitaker[5] and by Holmes[6] as an esker; but it has been interpreted by Carvill Lewis[7] as a beach deposit. The sands in it contain numerous fragments of marine shells including *Mytilus*. The base of this esker is at the level of about 50 feet O.D.; the best section is in a pit at its southern end. The uppermost

[1] Cf. *Proc. Norwich Geol. Soc.*, i, 1884, p. 272; *Mem. Geol. Surv.*, 65, 1893, p. 79.
[2] *Mem. Geol. Surv.*, 65, p. 75.
[3] *Mem. Geol. Surv.*, 65, 1893, pp. 75–9.
[4] *Geol. in Field*, p. 173.
[5] *Proc. Geol. Assoc.*, 1883, viii, p. 135; *Mem. Geol. Surv.*, 69, 1899, p. 88.
[6] Geol. Mag., 1883, p. 441.
[7] *Glac. Geol. Gt. Brit.*, pp. 340–1.

bed is a surface wash of angular broken flints; this rests on shell-bearing sands, or on boulder clay, which is sometimes in disturbed patches, but at the southern end of the pit occurs as a sheet 2 feet thick, resting upon an irregularly denuded surface of the sand. The foreign rocks in this boulder clay show that it belongs to the North Sea Drift. The bedded shelly sands were therefore deposited in a depression earlier than the North Sea Drift; and that the present form of the sand hills is due to denudation later than that Drift is shown by the angular flint gravel which caps them and which was formed as a wash down the sides of the valley. When this gravel was formed a continuous slope must have extended from the Chalk slopes to the summit of the ridge. Some outliers of the sands to the S.W. of the ridge support the conclusion that its form is due to denudation.

3. *The Blakeney Downs.*—The most esker-like formation which I have seen in East Anglia is that known as the Blakeney Downs, a sinuous bank of sand and gravel which lies on the high ground (80–150 feet above O.D.) to the W. and S.W. of Blakeney. Its course has been described by Holmes[1] and H. B. Woodward.[2] The structure is clearly shown in a series of extensive sections. The redeposition of some of the material has in places given rise to a dip parallel to the slopes. The most instructive sections are on the S.E. side of the road going S.W. from Blakeney. The surface layer is usually a residual bed, a foot or two thick, composed of closely packed flints. Beneath this layer is false-bedded fluvio-glacial gravel; this rests on the eroded surface of a lower series of similar gravels and bedded sands. The sides of this pit show the longitudinal variations in the deposits; but in spite of the clear and numerous sections along the ridge I saw no evidence of osar-like cross banding. The sections show that the original bedding of the fluvioglacial beds has been abruptly cut off on the margin by later denudation, and that on this worn surface was deposited a sheet of boulder clay, which, at the N.W. corner of the main pit, rests upon 12 feet of marl formed of redeposited Chalk and belonging to the North Sea Drift.

Isolated from the main ridge by level tracts of boulder clay are mounds of sands and gravel, such as Joe's Hill. Similar gravels are extensively developed on the opposite side of the River Glaven, E. of Wiverton, where they are shown in large pits.

The Blakeney "esker" is either part of a wide sheet of fluvio-glacial gravel, or of a kame formed before or during the deposition of the North Sea Drift; it contains biotite-gneiss and other rocks characteristic of that drift; but the boulder clay of that drift rests on an irregular eroded surface of the kame gravels. It may be residual from a widespread sheet of sand and gravel, or a denuded

[1] Geol. Mag., 1883, p. 441.

[2] *Mem. Geol. Surv.*, 68 S.W. and N.W., 1884, pp. 34, 35, 37; *Geol. Engl. and Wales*, 1887, p. 510; *Proc. Norw. Geol. Soc.*, i, pt. 8, 1884, p. 266.

kame formed near the margin of the ice which deposited the North Sea Drift.

4. *Cromer.*—The Lighthouse Hill at Cromer has been mentioned by Mr. T. V. Holmes as resembling an esker, but he explains it, and the Beeston Hills to the W. of Cromer, as "hills of circumdenudation"[1]. The Lighthouse Hills are sand-dunes resting on contorted drift.

VI. Cumberland—N. Lancashire.

The N. and W. Margin of the Lakes.—Kames and eskers have been described from N. Cumberland around Carlisle; they may be conveniently considered in connexion with the extensive series on the Scottish side of the Solway. Those near Carlisle have been described by T. V. Holmes[2] and J. G. Goodchild.[3] On the W. side of the Lake District, A. H. Green[4] described as eskers the gravel mounds in lower Ennerdale and explained them as tidal deposits; they occur where a kame might be formed along the sea front of the Ennerdale glacier.

2. *The Valleys of the Lake District.*—In the valleys of Cumberland and Westmorland numerous mounds have been described as eskers, e.g. at the mouth of Garsdale, N. of Fell Yeat,[5] in Milburn Beck, N. of Knock Pike, and Cosca Hill, E. of Knock Gill,[6] near Staveley and Kendal (½ mile S. of Loundes), and at Blea Beck Old Bridge, Shap Wells.[7] Professor J. E. Marr[8] has mentioned several and remarks their origin in various ways. Most of these formations seem to be due to the denudation of beds of post-glacial, or, as suggested in the *Mem. Geol. Surv.* for the ridge at Fell Yeat, of interglacial gravel. None of those mentioned which I have seen, or others of the same kind, appear to be either osar or kames.

3. *The Carnforth Gravels and Kames.*—The Carnforth gravels are of historic interest, as they were referred to by Buckland[9] as morainic in his classic paper on the British glacial deposits. Subsequently they have been referred to by Mackintosh.[10] The range of the S. part of the sheet of sands and gravels to which they belong is given on the Geol. Surv. Map, Drift Ed., 91 N.E.; but little definite information has been published regarding them. Professor Marr has kindly lent me the 6 in. maps of the area with many of his notes thereon, which were of much use in my visit. The gravels are seen from the L. & N.W. Railway at Carnforth Station, around which the best sections occur. Hawes Hill Pit, S. of the station and E. of

[1] Geol. Mag., 1883, p. 441.
[2] Geol. Mag., 1883, pp. 439–40; *Mem. Geol. Surv., Carlisle*, 1899, pp. 45–7.
[3] *Q.J.G.S.*, xxi, 1875, pp. 91, 92.
[4] *Geology*, 1876, pp. 470–1.
[5] *Mem. Geol. Surv.*, 97 N.W., p. 188.
[6] *Mem. Geol. Surv.*, 102 S.W., p. 98.
[7] *Mem. Geol. Surv.*, 98 N.E., 1888, pp. 42, 45.
[8] *Geol. Lake District*, 1916, pp. 179–80.
[9] *Proc. Geol. Soc.*, iii, 1841, p. 247.
[10] *Q.J.G.S.*, xxix, 1873, p. 354.

the railway, has an esker-like aspect at the S. end of the pit, as it has an arch bedding; but this structure is not due to deposition but to later movements. The core of this arch consists of a flat-topped block of gravel capped by laminated loam; above this loam is coarse gravel which sinks at each end of the section below a higher layer of the bedded loam. The former continuations of the bed capping the core has sunk, as would have happened if they had rested on imbedded masses of ice which had melted away; on the E. side the loam is bent down and is thinner, having been pulled out by the subsidence; on the W. side the layer of loam has been broken and the coarse gravels above rest through the breach directly on the core. The N. face of the pit, about 20 feet high, shows the typical gravels of Hawes Hill, which consist of an irregular succession of bedded sands and gravels; the main bedding is there horizontal with a slight general dip to the W.; the lower part of the section consists of coarse gravels with a dip to the W.; above are lenticular and irregular beds of sand and gravel, which are much false-bedded and show repeated contemporaneous erosion. The upper part consists of loams and gravels, and the horizontality of their main bedding is shown by three layers of loam which extend across the section with only a very slight dip to the W. Sections at right angles to this face show that the main bedding in the direction N. and S. is also nearly horizontal.

At the N.W. corner of Hawes Hill the upper layer is crowded with large boulders doubtless collected by the washing away of the finer constituents.

At the Locomotive Works W. of the railway, in a projection N. of the main shunting yards, the beds dip to the E. In the W. side of this section is a fault with a downthrow to the W. of 3½ feet. The beds consist of a succession of torrential gravels, and of fine gravels, sand, and loam. At the base is a bed of coarse gravel dipping E.; above it is a layer composed of three beds dipping more steeply to the E.; at the W. end is a wedge-shaped mass of fine gravel and sand; this is flanked to the E. by bouldery drift, which is in turn succeeded by brown sandy loam. These three beds are cut off above by a denuded surface, on which was laid a sheet of bedded sand and gravel, that is covered at the S. end by a bouldery wash. The dip of these beds to the E. and that at Hawes Hill to the W. indicates that the beds were deposited on the banks of a valley through which the Keer once discharged S. past Bolton-le-Sands. The drumlin known as Hunting Hill (150 feet high), which rises W. of the Locomotive Works, is part of the western bank of this old valley.

The gravel pits at Carnforth Bridge, which were probably those seen by Buckland, are now mostly overgrown; but a new section on the S. bank of the canal, 600 yards E.N.E. of the bridge, shows gravel at the base overlain by bedded sands, into which irregular channels have been cut and filled by coarse bouldery wash; at the

W. end of the section a vertical cliff had been cut into the lower gravel and sands, and coarse gravel dumped against the cliff, the bedding being almost vertical at the cliff face.

The Carnforth gravels are typical fluvioglacial deposits, laid down by torrential streams; I saw no striated boulders or contortions like those in drifts disturbed by ice; but there are faults such as have often been attributed to the melting of blocks of ice or frozen sand. Most of the boulders are of Carboniferous limestone, with an assortment of rocks from the N.; and this mixture of materials which were brought to the neighbourhood by ice justifies Buckland's description of the gravels as "detritus of moraines".

The arrangement of the gravels is not osar-like; the irregularity of the deposits is due to frequent contemporaneous erosion and to deposition by streams varying frequently both in strength and direction. There is no sign of regular seasonal banding.

The surface of the Carnforth gravels forms mounds with a few secondary ridge-like forms; but they seem due to erosion. According to the Geol. Survey Map (Sh. 91 N.E., Drift) the gravels extend S.E. past Thwaites House and end there abruptly on an E.W. line; the hills which rise to 208 feet, from about 160 feet, are shown by the map as part of the sands and gravels, but they appear to be drumlins of sandy boulder clay; the Carnforth gravels lay at a lower level, not rising above about 70 feet.

The boulders from the Lake District suggest the derivation of the Carnforth gravels from the N. down the valley followed by the road from Carnforth to Milnthorpe. Some of the hills near Burton-in-Lonsdale (4 miles N. of Carnforth) appeared from the railway to be kame-like; but those visited are of boulder clay with numerous striated boulders, as on the S. side of the wide "moss" S.W. of Burton Station. The furthest N. at which I have seen the Carnforth fluvioglacial gravels is on the W. side of the Milnthorpe road, S. of Yealand Conyers, $\frac{3}{4}$ mile N. of its junction with the Burton Road. The gravels there are coarse and cemented; they were clearly derived from boulder clay and deposited on the valley floor. Further S. the gravels spread out as a wide sheet and are worked in a shallow pit, N. of the Keer bridge; the bed is a typical fluvioglacial false-bedded sandy gravel with pockets of loam, such as is laid down on the flood plain of a rapid, shifting river. These deposits indicate that one source of the Carnforth gravels was a river coming down the valley from Burton and Kendal. Another contribution was received through the Keer valley from the N.E., past Kellet Bridge.

4. *The Kellet Bridge Kames.*—The best-developed ridges of glacial drifts near Carnforth are near Kellet Bridge, about 2 miles E.N.E. of Carnforth Bridge and at the level of 50 feet O.D. My attention was kindly called to them by Professor Marr. They consist of a double series of low ridges usually about 15 feet high. They are in places so regular and look so artificial that the farmer on

whose land some of them occur explained them as "made for fighting". The southernmost of the series is cut through by the railway just N. of Kellet Bridge; it follows the railway as a sinuous and in places wooded ridge, 15 feet high; there is no clear section, but the abundance of boulders is proved by the occurrence of thirty in one group S.E. of Alpha House. The nature of the material exposed on the surface and thrown out from rabbit burrows is glacieluvial.

The close association of these formations with ice is shown by an excellent section through one ridge in a gravel pit N. of the High Keer Bridge on the road from Kellet to Burton. This section is 15 feet high, and it shows three layers; the lowest, exposed on the E. side, is gravel with a base of brown loam; above this is a bed crowded with large well-washed boulders (up to 3 feet in diameter); this boulder bed is covered by gravel. This section may be explained by the deposition first of a low bed of gravel in front of a glacier; a re-advance of the ice led to the deposition of the large boulders, which were covered by gravel when the ice again retreated. The Kellet Bridge ridges are not osar, as they show neither seasonal banding or fluvioglacial action. They are glacieluvial kames deposited along the edge of ice which apparently came from the N.E., and spread over the low ground of the Keer valley and ended on its S. slope.

VII. Isle of Man.

Opposite Carnforth at the N. end of the Isle of Man a line of high kames known as the Bride Hills, trends E. and W. across the island. They have been described by Lamplugh.[1]

VIII. S.W. Lancashire and Cheshire.

A mound of "esker drift" at Pickering Castle, N.E. of Chorley, has been mentioned by de Rance.[2] The sand ridges on the Cheshire plain at Beeston and near Delamere, have been regarded as eskers.[3] From the account by G. H. Morton [4] these beds belong to the "Middle Glacial", and he describes them as having evidently originated as sand-banks. Those which I have seen are residual banks left by the denudation of the interglacial sands.

IX. The Midlands.

A number of especially interesting "eskers" have been described from the western Midlands. Professor Boulton [5] has published an instructive account of an example near Kingswinford which extends for 4 miles on a N.N.W. course, and passes 1 mile N.W. of Stourbridge. Professor Boulton describes the beds as contorted and as

[1] *Geol. I. of Man*, 1903, pp. 353–8.
[2] *Mem. Geol. Surv., S.W. Lancashire*, 1877, p. 44.
[3] H. B. Woodward, *Geol. England and Wales*, p. 490; Strahan, *Mem. Geol. Surv.*, 80 S.W., 1882, p. 17.
[4] *Geol. Country around Liverpool*, 1897, pp. 209–10.
[5] *Proc. Birmingham Nat. Hist. Soc.*, xiv, 1916, pp. 25–35, pl. v, vi.

faulted by the melting of included ice, and as containing "beautifully laminated" mud. He describes it as built up of a series of semi-cones deposited by a sub-glacial river, which came from the N. and discharged into a sheet of water near the ice margin (ibid., p. 30, 33). Transverse to the main ridge are several kames (ibid., p. 32). The level of this formation is from 200–75 feet above sea level. The valley in which it lies was preglacial (ibid., p. 35).

Professor Boulton's account of this formation gives the first proof of English osar. Mr. E. E. L. Dixon has kindly informed me of some branching gravel ridges which he is investigating at Newport, Shropshire, and of which he will publish a description shortly. He describes the series as branching and each branch as becoming alternately wider and narrower; and this moniliform character combined with other features indicates that these formations are also osar. Professor Boulton tells me that they belong to the same series as that of Kingswinford.

Midland eskers have been recorded from the Longmynd, where they are said to occur to the height of 900 feet on the N.E. flank; N.W. of Buildwas and Strethill [1]; near Oswestry, as A. C. Nicholson [2] has called the Gloppa shell beds "a ridge of eskers" 1,000 yards long; and irregularities like esker mounds rise from beneath the "unbedded drift" (interglacial) near Four Oaks, 6 miles S. of Lichfield, and near Hopwas, W.N.W. of Tamworth.[3] I have not visited these formations except at Gloppa, which on my visit was enveloped in so thick a mist that I could see practically nothing of the field relations of the shell-bearing sands.

The Midland records relate to localities in the area containing morainic drift. To the S. and E. of that area there are no kames; for example, the gravels of the Malvern district, according to J. Gray,[4] are preglacial.

X. Welsh Eskers.

1. *N. Wales.*—On the mainland of N. Wales the best-known formations referred to as eskers are in Flintshire around Mold. Some curvilinear banks of shell-bearing sand and gravel were there described by Mackintosh [5] as "sand-eskers". He recorded them to heights of 800 feet above sea level near Brynford, and of 950 feet at Moel-y-Crio. They and other examples have been also described by Sir Aubrey Strahan,[6] who refers to numerous eskers and describes (op. cit., p. 139) that at the height of 982 feet on Moel-y-Crio, S.W. of Halkin, as "the most conspicuous in all this part of Wales". It contains shell fragments. Most of these eskers are at low levels along the valleys, such as Bailey Hill in Mold; at Hartsheath in

[1] *Geol. Assoc., Geol. in Field*, pp. 764–5.
[2] *Q.J.G.S.*, xlviii, 1892, p. 86.
[3] *Mem. Geol. Surv.*, 154, 1919, p. 179.
[4] *Proc. Birmingham Nat. Hist. Soc.*, xiii, 1914, p. 17.
[5] *Proc. Geol. Soc. Liverpool*, iv, 1883, p. 361.
[6] *Mem. Geol. Surv.*, 79 S.E., 1890, pp. 130, 131, 135, 137, 139, 142.

the Alyn valley, S.E. of Mold, where two eskers rise through the alluvium, the most esker-like occurring between two tributaries to the Alyn; at Maes-y-groes in the upper Alyn Valley, about 3 miles W. by N. from Mold; and at Sarn Mill and at Groessffordd, in the valley of the Chwyler. The low level eskers appear to be all denuded remnants of a sheet of sand and gravel interstratified between two boulder clays. They are usually ridge-like because they are due to denudation along the valleys. It is worthy of notice that these gravels are near the line marked by Sir A. Strahan as the margin of the North Welsh ice.

2. *Anglesey.*—Mr. Greenly has described a series of "eskers" in Anglesey.[1] From his account they appear to be fluvioglacial in origin, and to be restricted to low levels on the margins of the island, ranging in level from 100–239 feet.

3. *Central Wales.*—A ridge 120 feet high of stratified false-bedded glacial gravel, sand, and clay across the Ystwyth Valley, at Llanrhystyd Road Station, S.E. of Aberystwyth, has been described as an esker by W. Keeping.[2] He refers to its aspect as like that of moraines, but says "its structure is totally different". The pebbles are "so little waterworn" that they retain glacial striæ and are subangular. It appears to be part of a bar deposited on the front of the ice sheet that descended the Ystwyth valley; as seen from the railway, which exhibits a good section through it, the formation is kame-like in aspect; Keeping's excellent account of this formation indicates that it is a glacieluvial kame, formed, as he remarks, where the Ystwyth valley opens out to a plain near the sea.

4. *S. Wales.*—Sir A. Strahan has described some of the gravel hills near Abergavenny and Newport as eskers.[3] They appear to be residual hills due to the denudation of the great sheet of fluvio-glacial gravel which was deposited in the Usk Valley along the S.E. edge of the S. Wales glaciers.

XI. The Distribution and Classification of the English Kames, Eskers, and Osar.

From the evidence in the foregoing summary the English "eskers" may be classified as follows:—

Osar: Kingswinford and Newport, Salop.

Kames:—

Fluvioglacial: Bingley; Panton; Blakeney; Anglesey; S. E. Northumberland.

Glacieluvial: Lucker; Elsdon; Kellet Bridge, near Carnforth; Llanrhystyd.

Residual: Wark; Bowmont Water; W. Durham; Durham City; Hunstanton; Usk Valley.

[1] *Mem. Geol. Surv., Anglesey*, 1919, vol. ii, pp. 706, 725, 730, 741, 749–50, 759, 762.

[2] Geol. Mag., 1878, p. 541; 1882, p. 256.

[3] *Mem. Geol. Surv.*, S.W. Coalfield, ii, 1900, pp. 89–90; Newport, 249, 1899, pp. 81–2.

The only known osar are those of Kingswinford and Newport (Salop). Kames are numerous, and may be grouped into three geographical series. The eastern series includes those formed along the margin of the Cheviot ice in Northumberland and Durham, and further S. the kames of Brandesburton, E. Lincolnshire, and Blakeney, which were probably deposited along the W. margin of the North Sea ice. The second series occurs along the probable E. margin of the ice sheets that flowed from the mountains of Wales and N. England; it includes the Roman Ridge near Ripon, the kames of the Aire Valley near Bingley, of E. Cheshire, those near Lichfield, and the mounds of the Monmouthshire Usk on the E. margin of the S. Wales ice. The third series lies along the former W. edge of the English ice sheet and was deposited at intervals during its retreat; this series includes the kames of the Solway; Ennerdale; near Carnforth (though the Kellet Bridge kames were formed along the S.E. margin of a lobe of this ice); in the Isle of Man; Anglesey; and near Aberystwyth. The kames are not all of the same age; some, e.g. those at Kellet Bridge and of the coast of Northumberland, belong to the last glaciation; while others, e.g. those in E. Lincoln, Hunstanton, and Blakeney, are interglacial, being overlain by boulder clays belonging to the North Sea Drift.

The kames and osar agree in being restricted to comparatively low levels; usually below 200 feet O.D., but those in E. Durham rise to 500 feet above sea level. The Lanshaw Delves are excluded as a moraine and the shelly sands at Gloppa, Moel-y-Crio, etc., as not true kames. This restriction of kames both in height and horizontal range may be due to the deposits having been accumulated in ridges instead of spread out in sheets, owing to the ice having entered a sheet of water. This view has been expressed by Green for the kames of Ennerdale and Airedale, by Keeping for that near Aberystwyth, by Professor Boulton for that of Kingswinford, and by Dr. Smythe for those of S.E. Northumberland;[1] and it is in accordance with the explanation adopted for kame and osar formation in other countries.

The distribution of the kames and osar is shown on the sketch-map, fig. 1,[2] upon which is also shown, modified in places, Carvill Lewis' line marking the position of the terminal moraine, which, according to him, marked the limit of the English land-ice. The line requires modification, for Lewis' later observations showed that the range of the land-ice was in places wider than he had at first recognized, as around Birmingham, and was elsewhere less extensive, as in N.E. Yorkshire. The kames are naturally not continuous all along that line, for they are readily destroyed by denudation; and on the view that they were formed where the ice entered water, they would not be found where the ice-front crossed what is now

[1] *Trans. N.H.S. Northumberland*, iv, 1910, p. 111.

[2] For help in this map I am indebted to Mr. M. A. Peacock.

higher ground. The frequent occurrence of the kames near Carvill Lewis' terminal moraine line is significant, and the absence of them and of osar from S. Yorkshire and from most of the Midlands and East Anglia supports other evidence that nearly all that country was free from land-ice. If England had been covered by glaciers as far S. as the Thames valley, it is strange that neither kames nor osar have been found in the E. Midlands or anywhere S. of Mid-Yorkshire, with the exception of occasional kames along the W. and S. margins of the North Sea ice. The rarity of osar is also significant, since if they were the casts of glacial rivers they would be expected on the high ground as well as on the lowlands.

REVIEWS.

THE GEOLOGY OF THE IGNEOUS ROCKS OF ESSEX COUNTY, MASS. Bull. 704, U.S. Geol. Surv. By CHARLES H. CLAPP. pp. 132, 18 plates, 4 figs., and insert. 1921.

THE writer differs from other workers in distinguishing two periods of batholithic intrusion, the earlier being post-Ordovician and subalkaline and the later alkaline and of Devonian or Carboniferous age.

The calc-alkali series ranges from granodiorite (68·94 per cent SiO_2) to gabbro-diorite (45·32 per cent SiO_2), transitional varieties being developed. All these rocks show in places a gneissose or even schistose structure with development of secondary minerals of dynamic metamorphism; the comagmatic characteristics are high FeO and TiO_2, and a predominance of Na_2O over K_2O. With regard to the differentiation of this series, the author states that "it appears as if this batholith is an ideal example of the differentiation in place of an original basaltic magma through fractional crystallization under gravitative control." A table of specific gravities is given. The variation diagram corresponds with the Pacific diagrams of Harker, though the curves are more linear.

The first rocks of the alkaline series to be discussed are the Lynn volcanics, which range in composition from quartz-keratophyres to andesites. They were erupted through and accumulated on a weathered surface of the granodiorite mentioned in the last paragraph, and are cut in places by the alkaline plutonic series.

The most acid member of the plutonic alkaline series is the Quincy granite, which consists essentially of quartz, microperthite, albite, and kataphorite; hedenbergite being essential in some varieties. The average composition of the microperthite is 52 per cent orthoclase, though the extreme limits show 37 and 68 per cent of orthoclase. Apophyses of the granite consist of granite dykes with aplites and pegmatites, the latter always showing a medial portion of ? β quartz. Porphyritic varieties of the granite appear at the margins. Schlieren of a slightly lower silica percentage are common in the granite.

The writer groups the pulaskites, umptekites, and hedrumites under the head of Beverly syenites. The pulaskite contains a green alkali-rich amphibole, like the kataphorite of the Quincy granite. Microperthite and aegirite are typical of the pulaskites and hedrumites, which by decrease of aegirite and increase of green hornblende pass into the umptekite, and this the author believes to be a hybrid between the pulaskite and gabbro-diorite. The nordmarkites (akerites of Washington) are transitional rocks between the syenites just dealt with and the granite.

The author distinguishes as Squam granite the nordmarkite of Washington (quartz-diorite of Shaler). No new description is added

to the nepheline-syenites described by Washington as foyaites and ditroites.

A great number of types of dykes have been distinguished showing a range from paisanites to camptonites.

With regard to the structure of the area three main faults have been distinguished, and there is a great deal of minor faulting. The main folding apparently took place a short time before the intrusion of the alkaline batholith.

Shatter-breccias are well-developed at the margins of the intrusions, but there is little evidence of marginal assimilation producing variation at the edges of the batholith. There is, however, a great deal of assimilation producing hybrid rocks by the commingling of two types, and descriptions are given of hybrids developed at the junction of the alkali and calc-alkali series. It is shown that extensive hybridism is not confined to interaction of magma and cognate xenoliths, but may take place between magma and relatively cold country rock.

J. E. A. W.

IMPERIAL INSTITUTE: MONOGRAPHS ON IMPERIAL RESOURCES WITH SPECIAL REFERENCE TO THE BRITISH EMPIRE: PETROLEUM. Prepared jointly with H.M. Petroleum Department, with the co-operation of H. B. CRONSHAW, B.A., Ph.D. pp. x+110. London: John Murray, 1921. Price 5*s.* net.

MUCH literature has appeared in the past few years in connection with the petroleum resources of the world, both in this country and America, but being of a decidedly popular or commercial nature, it has usually suffered from the lack of scientific treatment. The time is undoubtedly propitious for the publication of an official volume (at a reasonable price) giving a concise and straightforward account of the known occurrences of oil, and indicating also the chief geological, physical, and chemical factors involved in each instance. Such a monograph as this should naturally command a wide circulation, and having a distinct educational value, we welcome its appearance accordingly.

While essentially a compilation, the book is not simply a mass of incoherent facts; those responsible for the text have been careful to avoid mere tabulation by prefacing the descriptive sections with an introductory chapter dealing with the characteristics, occurrences, mining, refining, and uses of petroleum. The world's resources are then discussed under two main headings, those of the British Empire (including Mandatory Territories), and those of foreign countries. In the former case, apart from the well-known fields, such as Burma, Egypt, and Trinidad, much up-to-date information is given concerning prospects in regions of which less is known of their oil potentialities; these comprise among others Malta, Cyprus, Mesopotamia, Palestine, British Cameroon, Sudan, Nigeria, Somaliland, and British Guiana. Such data is of the greatest

possible importance, for while extensions are naturally to be sought in existing fields, it is just as vital that attention be focussed on the location of new and likely areas whose resources are as yet imperfectly realized. The small oil map of the world included on page 89 shows in a striking manner, however, the unfortunate divorce between the geographical situations of our colonies and those of the main petroliferous provinces of the world; so much country has unfortunately to be "ruled out" as impossible, from tectonic considerations.

Of the foreign resources one of the most interesting areas is undoubtedly that of Sakhalin (Russia) with its oil belt stretching along the Pacific coast for nearly 200 miles; though geologically complex, the indications are good, and an asphalt lake near Oha Creek, alleged to contain 25,000 tons of raw material, is not the least of these. Parts of Central America and Colombia also hold out great possibilities, while exploration in Venezuela, though slow and intermittent in the past, is now meeting with deserved success.

Statistics of production are given in most cases, together with the results of refining the various crude oils obtained. The amount of geographical and geological information included is surprising for a volume of this size; it is essentially the embodiment of this information to the exclusion of irrelevant commercial matter that sets a real value on the monograph, and we may express the hope that it will be widely read, not only by the scientific worker, but also by the general public.

H. B. Milner.

Silver Ores. By H. B. Cronshaw. Imperial Institute Monographs, pp. ix + 152, with 1 map. London: Murray, 1921. Price 6*s.* net.

One of the most striking facts concerning the silver production of the world from the mining and geological point of view is that about four-fifths of it is obtained as a by-product from the mining and metallurgical treatment of ores exploited mainly or largely for other metals, gold, copper, lead, and zinc. In many cases, however, the economic working of these ores would be impossible but for the added value derived from the silver. Hence it is somewhat difficult to define what is really an ore of silver. The ore-deposits in which silver is the dominant metal show many interesting features, especially with regard to the phenomena of oxidation and formation of zones of secondary enrichment, while some of the deposits of native silver are very remarkable.

In this monograph are brought together accounts of all the important silver deposits of the world; in a few cases, where the silver is essentially a by-product, the author has wisely contented himself with giving references to other works, when such are well-known or easily accessible; such are, for example, the lead-silver ores of England. It is a curious fact that the galena of Yorkshire